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**Fischer et al.**

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(54) **UPRIGHT FIRE PROTECTION NOZZLE**

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(73) Assignee: **Grinnell Corporation**, Cranston, RI (US)

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This patent is subject to a terminal disclaimer.

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(22) Filed: **May 22, 2001**

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**Related U.S. Application Data**

(63) Continuation-in-part of application No. 09/603,686, filed on Jun. 26, 2000, now Pat. No. 6,454,017.

(51) **Int. Cl.**[7] ................................................ **A62C 37/08**
(52) **U.S. Cl.** ............................ **239/37**; 239/38; 239/39; 239/40; 239/41
(58) **Field of Search** ............................ 169/37, 38, 42, 169/16, 17, 39–41; 239/498, 504, 518, 523, 524

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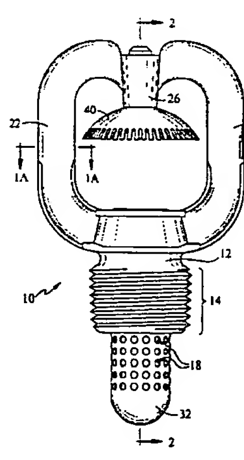
(57) **ABSTRACT**

An upright-type fire protection water spray mist nozzle has a base defining an orifice through which fire-retardant fluid can flow, an inlet section having an upstream end and defining a conduit for flow of fire-retardant fluid along a orifice axis and leading to an upstream end of the orifice, with a diffuser element defining an impingement surface that is at least substantially imperforate in an axial direction and positioned for impingement by a stream of fire-retardant fluid flowing from the orifice in a stream direction along the orifice axis, the diffuser element being positioned generally above a horizontal plane through a downstream end of the orifice.

**35 Claims, 8 Drawing Sheets**



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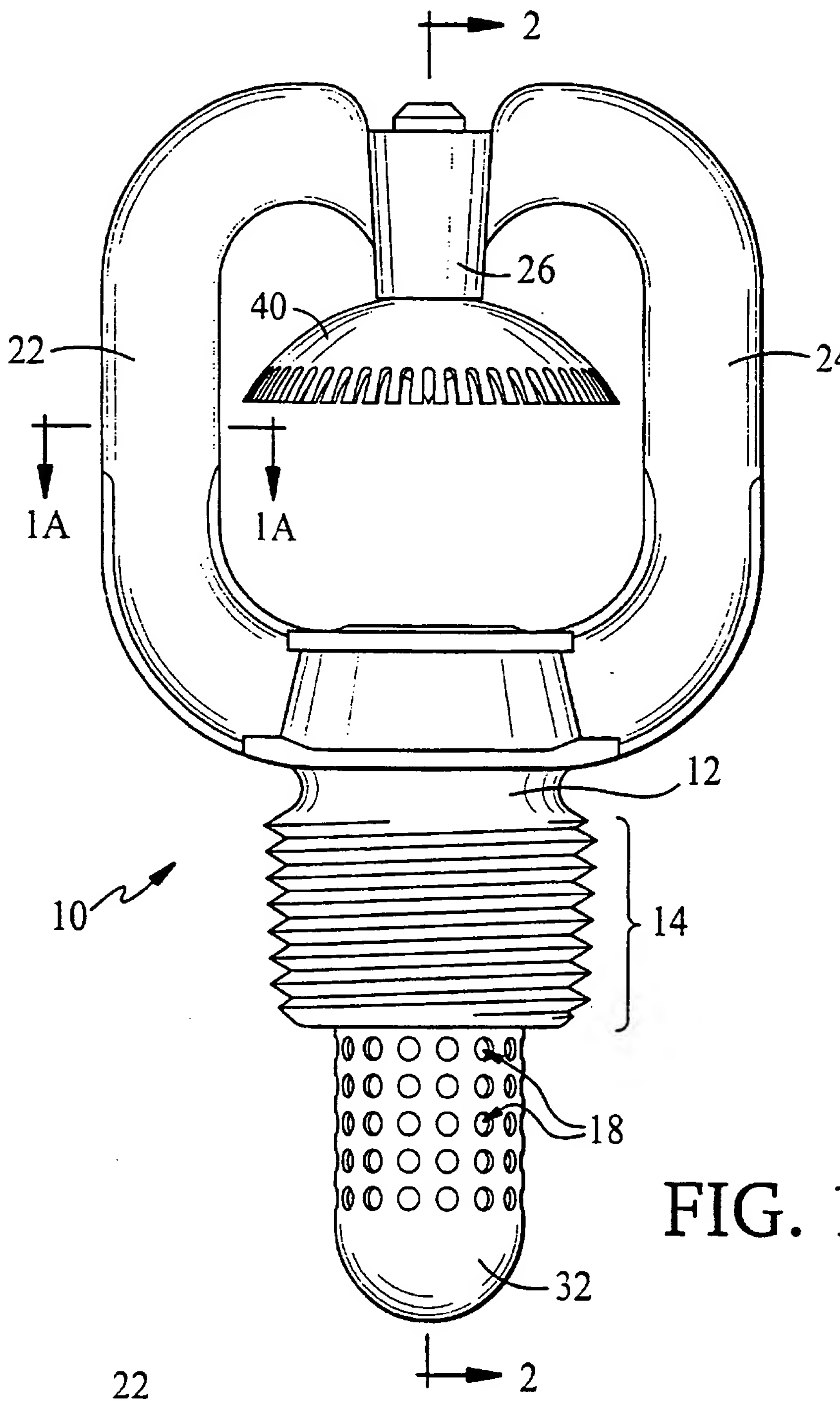



FIG. 1

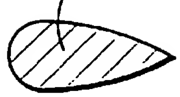



FIG. 1A

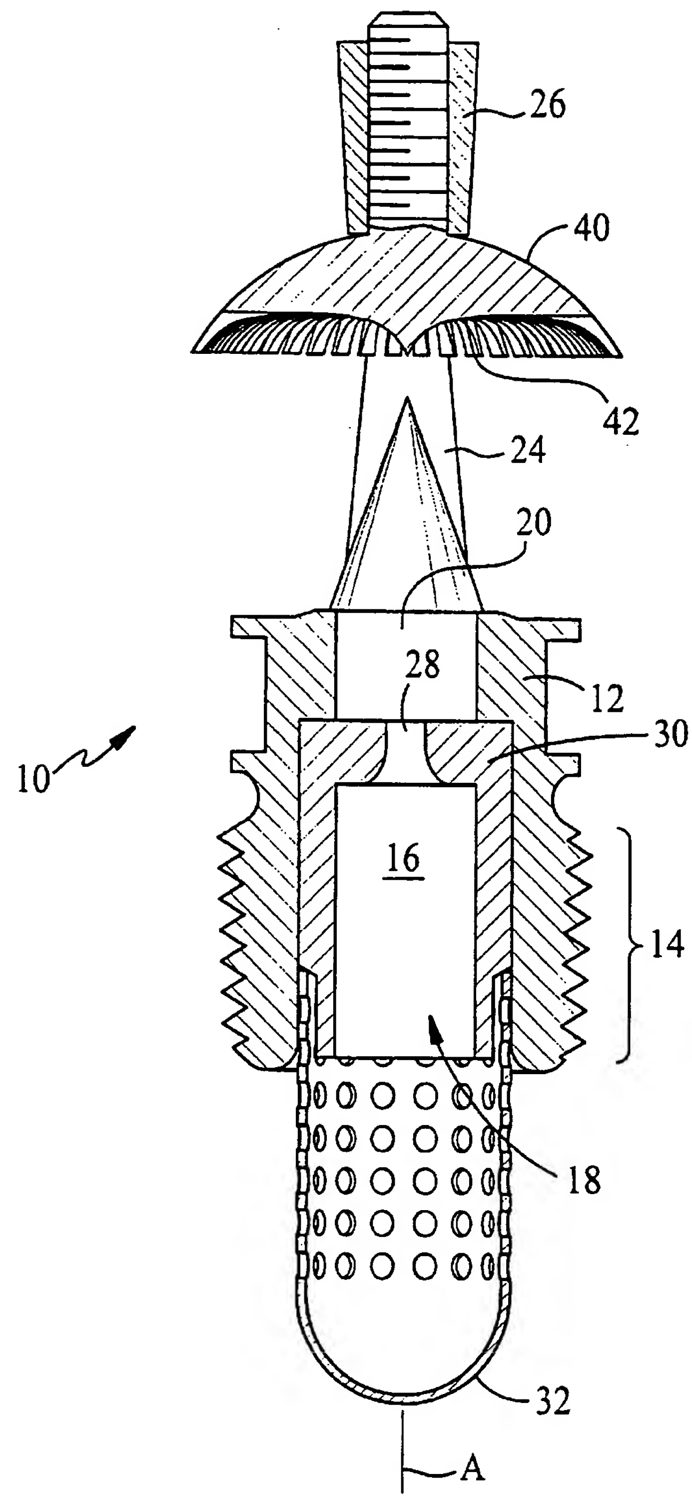



FIG. 2

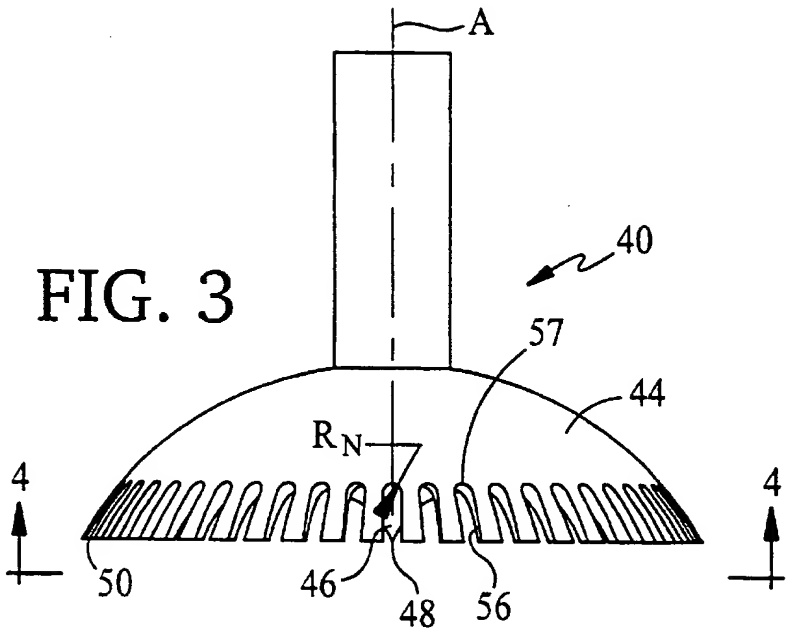



FIG. 3

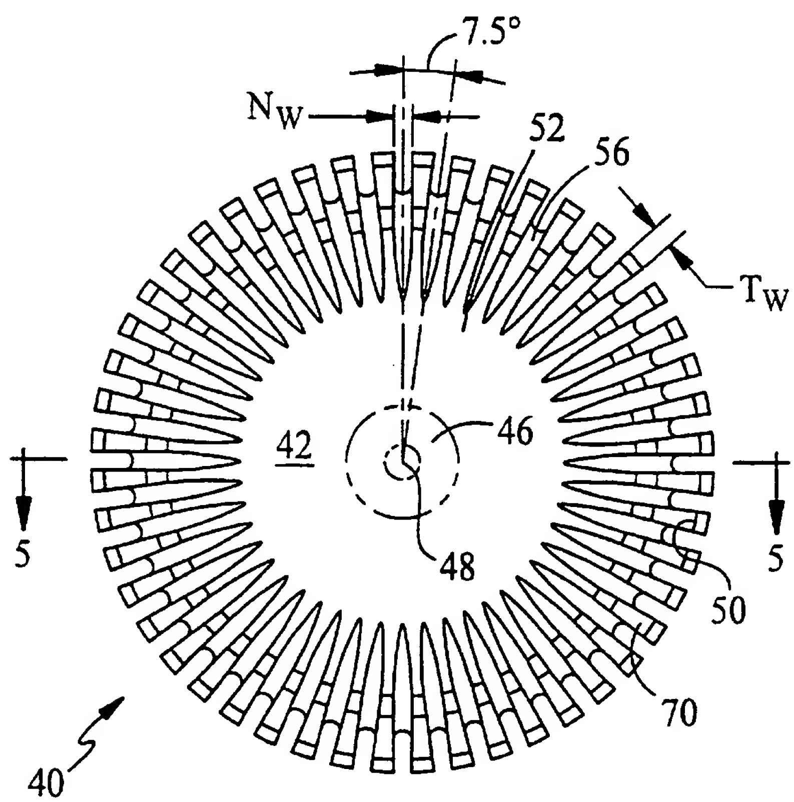



FIG. 4

FIG. 5

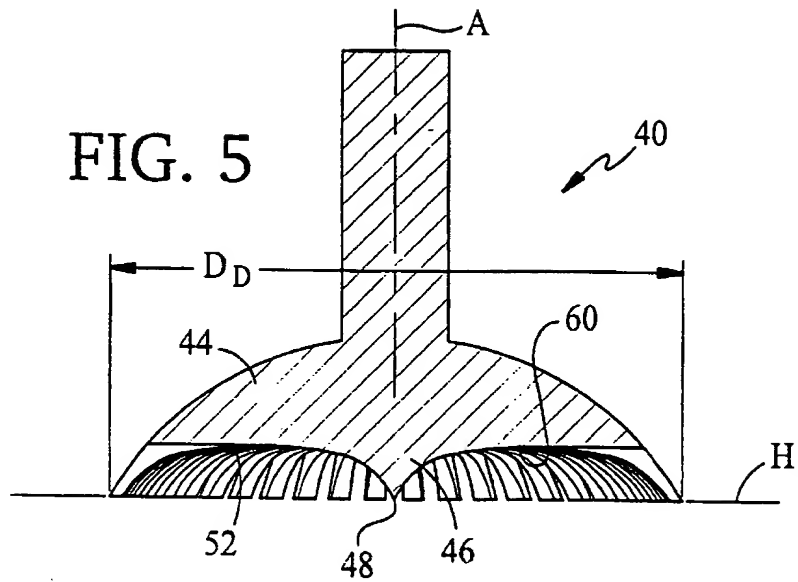
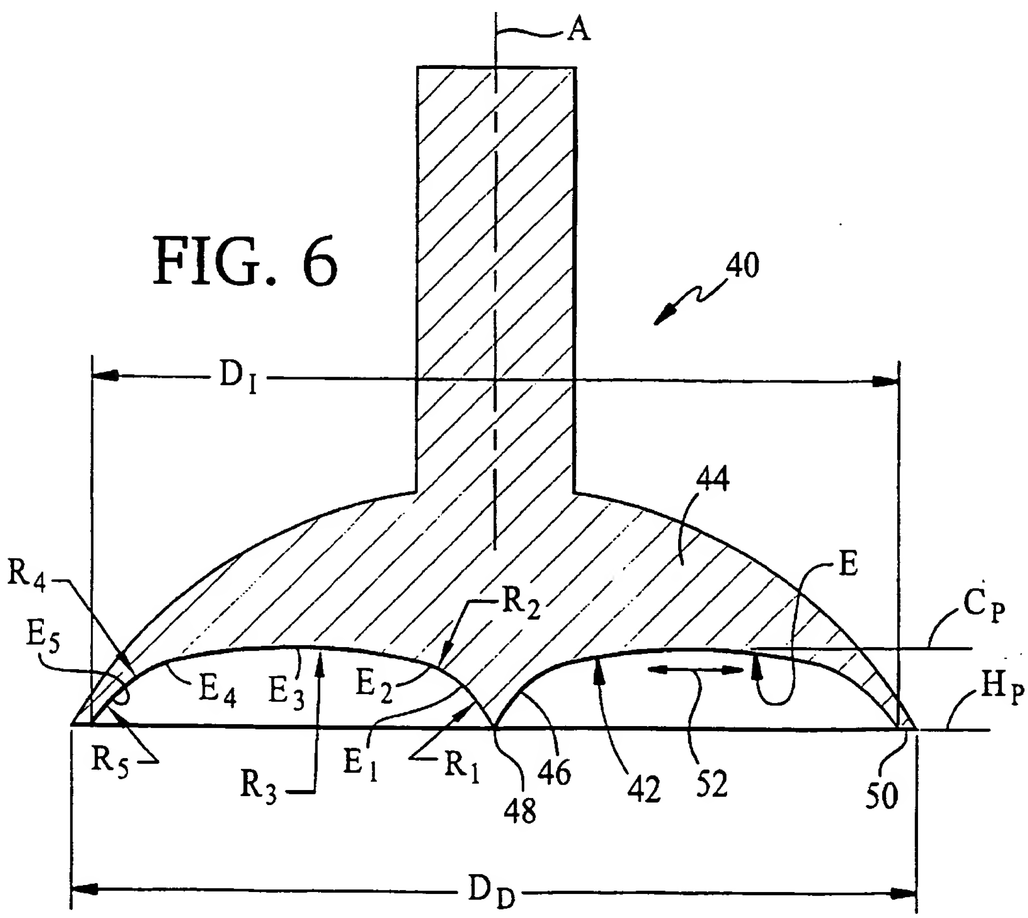

A
40
$D_D$
44
60
$H_P$
52
48
46

FIG. 6


A
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52
50
48
$D_D$

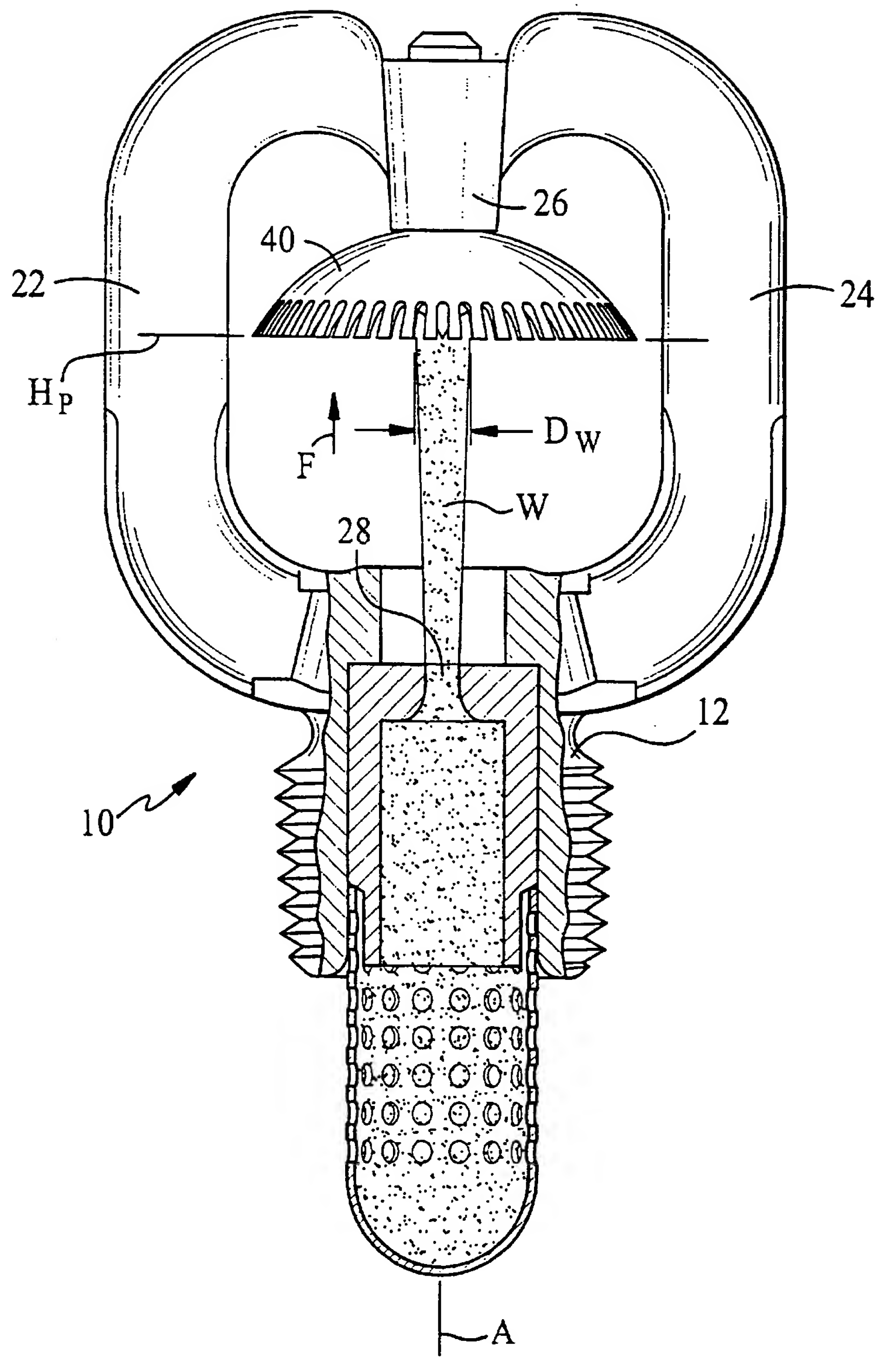


FIG. 7

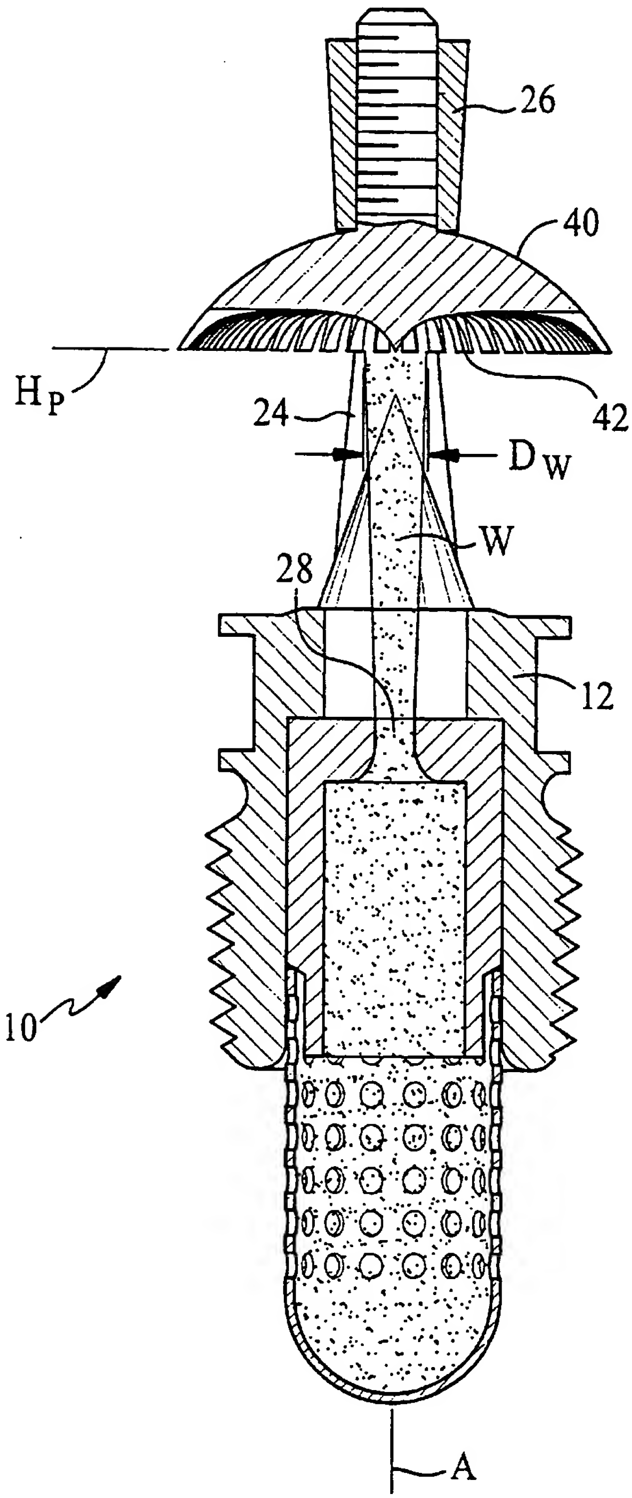


FIG. 8

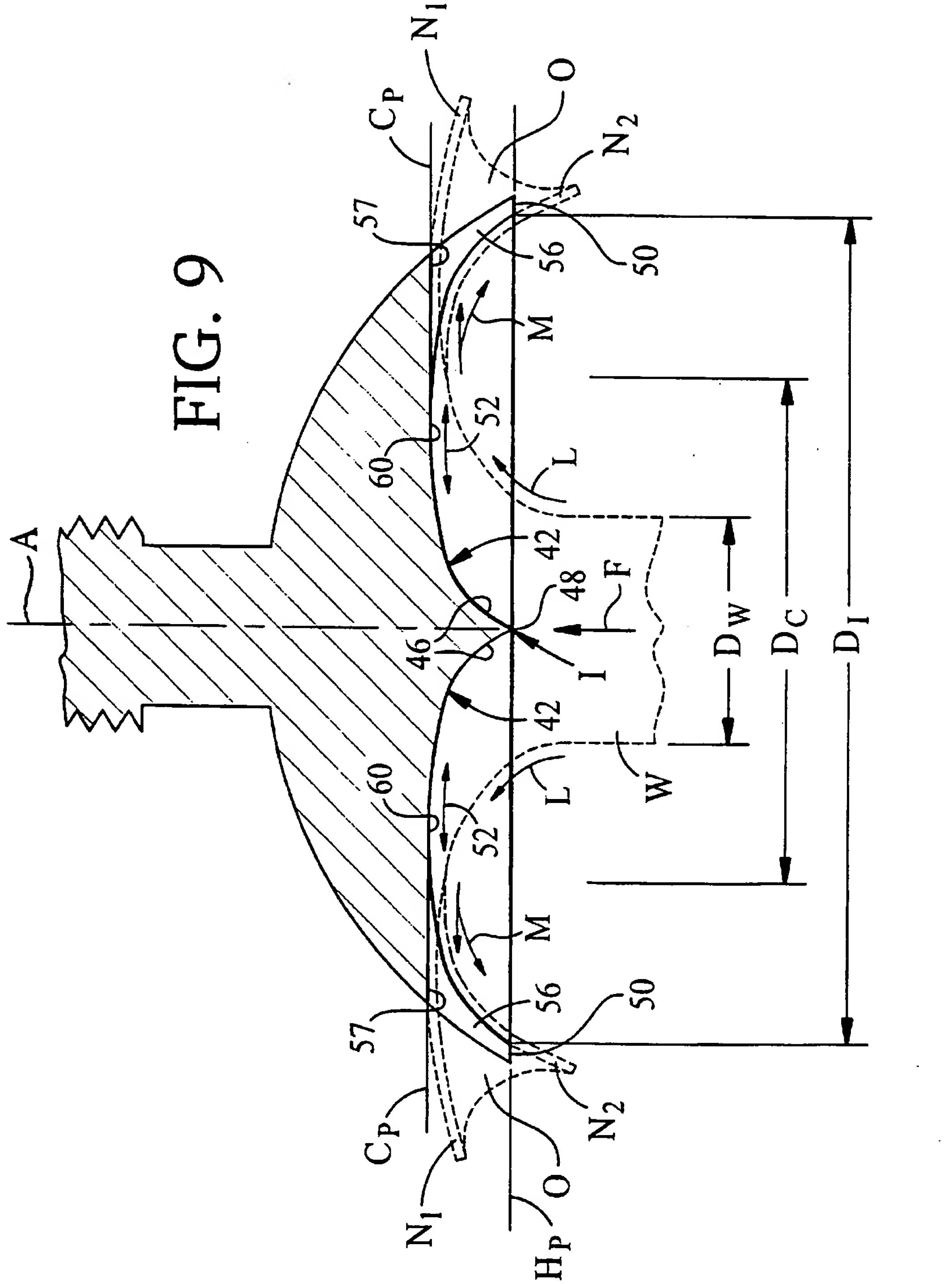


FIG. 9

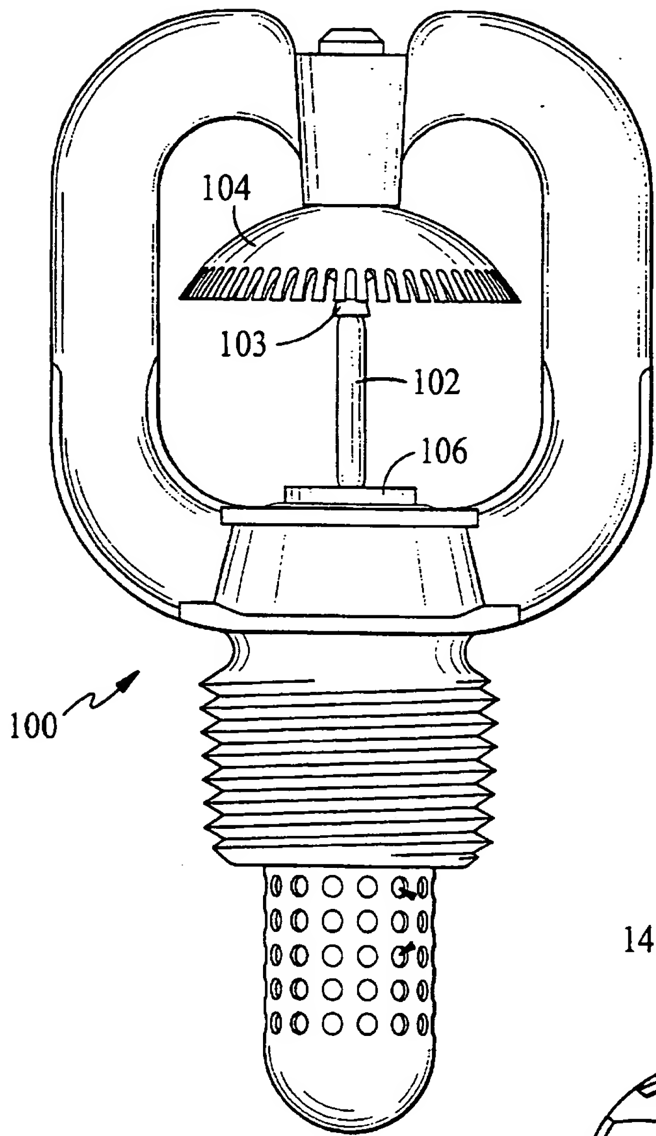


FIG. 10

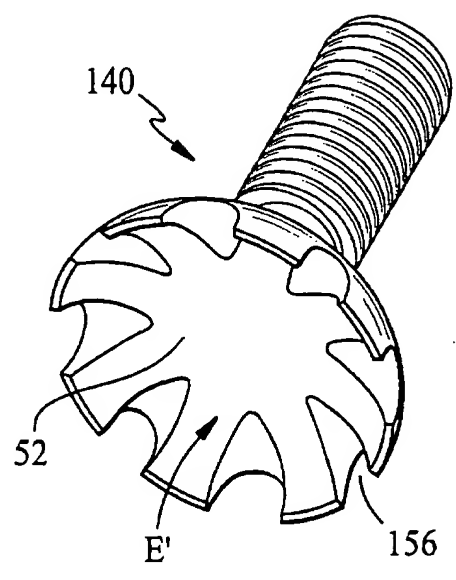


FIG. 11

# UPRIGHT FIRE PROTECTION NOZZLE

This application is a continuation-in-part of U.S. application Ser. No. 09/603,686, filed Jun. 26, 2000, and now U.S. Pat. No. 6,454,017, the entire disclosure of which is incorporated herein by reference.

## TECHNICAL FIELD

The invention relates to water spray sprinklers and nozzles for fire protection service, and, in particular, to those nozzles in which a single stream of water is discharged and impacts or impinges against a downstream element as a means of deflecting, spreading or diffusing the discharge stream into a spray pattern consisting of individual droplets.

## BACKGROUND

Water sprays consisting of relatively small or fine water droplets, commonly referred to as "water mist", have been shown to be among the most efficient fire extinguishing media currently available. Small water droplets suspended in the atmosphere can be forcibly injected or entrained through the convective currents, into the combustion region of a fire, where they quickly evaporate. The evaporation of these droplets has an impact upon the combustion process by absorbing some quantity of the energy output of the fire, and by displacing gaseous oxidizing agents. At some critical point, when the fire is no longer capable of self-sustained combustion, it is extinguished. It has been shown that droplets of less than 50 microns in size are extremely efficient fire extinguishing agents. As droplet size increases, the efficiency of the fire extinguishing media, typically water, decreases, although it has been demonstrated that water mist with the majority of the droplets between 20 and 250 microns in size can be highly effective and efficient fire extinguishing agents, particularly when delivered in a componentized spray pattern. Fischer U.S. Pat. No. 5,839,667 teaches that it can be desirable to selectively provide areas of higher water discharge per unit area, greater droplet size, and/or greater droplet momentum. It has also been shown that different expected fire scenarios may require different spray pattern characteristics, if the effectiveness of fixed fire fighting system is to be maximized.

The main types of water mist nozzles for fire protection include diffuser impingement nozzles, pressure jet nozzles, and gas atomizing nozzles. Diffuser impingement nozzles operate by impacting a coherent water stream against a diffuser. The diffuser breaks the stream into a predetermined distribution of mist. Diffuser impingement-type water mist nozzles are described in Fischer U.S. Pat. No. 5,392,993 and in Fischer U.S. Pat. No. 5,505,383. Pressure jet nozzles function by discharging high velocity water streams through small orifices with an internal shape, e.g., a scroll-type arrangement is typical, designed to break up the water stream. A pressure jet type water mist nozzle is described in Sundholm U.S. Pat. No. 5,513,708. Gas-atomizing water mist nozzles operate by mixing compressed gas with water in a mixing chamber at the nozzle discharge orifice. A gas atomizing water mist nozzle is described in Loepsinger U.S. Pat. No. 2,361,144.

The spray pattern characteristics produced by existing diffuser elements utilized in impingement-type water mist nozzles fall into two distinct categories. The first category is a relatively uniformly filled, umbrella-shaped spray pattern extending from the discharge nozzle. The second category is a largely hollow cone, with the spray pattern forming a uniform or non-uniform shell of spray. Fischer U.S. Pat. No. 5,829,684 describes a nozzle producing a combination of these two fundamental types, with a uniform, umbrella-shaped shell superimposed over a relatively uniformly filled inner cone.

## SUMMARY

According to one aspect of the invention, an upright-type fire protection spray mist nozzle comprises a base defining an orifice, with an orifice axis, through which fire-retardant fluid can flow, an inlet section having an upstream end and defining a conduit for flow of fire-retardant fluid along the orifice axis and leading to an upstream end of the orifice, and a diffuser element positioned coaxially downstream of the orifice, the diffuser element defining an impingement surface that is at least substantially imperforate in the axial direction and positioned for impingement by a stream of fire-retardant fluid flowing from the orifice in a stream direction along the orifice axis. The impingement surface comprises a central conical shape surface region extending generally toward the orifice, with an apex portion disposed along the orifice axis, a peripheral edge disposed generally radially outward from the conical shape surface region and defining a face plane, and a concave, substantially toroidal surface region generally between the conical shape surface region and the peripheral edge.

Preferred embodiments of this aspect of the invention may include one or more of the following additional features. The apex and the peripheral edge are disposed in a plane generally perpendicular to the orifice axis. Preferably, at least a portion of the toroidal surface region is recessed downstream from the plane of the apex and the peripheral edge, relative to the orifice. More preferably, the toroidal surface region is recessed downstream from the plane of the apex and the peripheral edge, relative to the orifice. The stream of fire retardant fluid flowing from the orifice to impinge upon the impingement surface is substantially steady and coherent. The concave, substantially toroidal surface region has a shape formed by rotation of an arcuate surface comprised of at least three relatively smoothly blended arcs, and preferably at least five relatively smoothly blended arcs, about a line defined by the orifice axis passing through the apex. The impingement surface defines at least one surface discontinuity in a region of the peripheral edge for redirecting a portion of the flow of fire retardant fluid along the impingement surface. Preferably, the impingement surface defines a set of surface discontinuities spaced circumferentially about the orifice axis in the region of the peripheral edge for redirecting a portion of the flow of fire retardant fluid along the impingement surface. The set of surface discontinuities generally has the form of a set of notches in the impingement surface. Preferably, the set of notches defines a set of surface regions extending along and outwards from a plane generally tangent to a base region of the concave surface and lying generally perpendicular to the orifice axis, towards the region of the peripheral edge. The set of surface discontinuities comprises a set of at least about eight notches, preferably a set of at least about 16 notches, more preferably a set of at least about 32 notches, and still more preferably a set of at least about 48 notches, in the impingement surface. The stream of fire retardant fluid flowing from the orifice and intersecting the impingement surface has a stream diameter measured as the stream is about to pass through the face plane, and a ratio of the diameter of a region of the concave surface lying generally tangent to a plane that is generally perpendicular to the orifice axis and the stream diameter is greater than or equal to about 2, preferably greater than or equal to about 3, and

more preferably greater than or equal to about 4. The peripheral edge has an inner edge diameter measured in the face plane and the stream has a stream diameter measured as the stream is about to pass through the face plane, and a ratio of the inner edge diameter to the stream diameter is at least about 3, preferably at least about 5.5, more preferably at least about 8, and still more preferably of the order of about 20. Preferably, the set of surface discontinuities divides the flow into multiple segments at the region of the peripheral edge with little loss of energy. The upright-type fire protection spray mist nozzle may be in the form of an open nozzle for use in deluge-type fire protection systems, or may be in the form of an automatically-operating nozzle comprising, in a standby condition, a releasable orifice seal secured in position by a thermally-responsive element, or may be in the form of a device remotely actuatable, e.g., in response to a fire condition determined by a separate fire detector.

According to another aspect of the invention, an upright-type fire protection spray mist nozzle comprises a base defining an orifice, with an orifice axis, through which fire-retardant fluid can flow, an inlet section having an upstream end and defining a conduit for flow of fire-retardant fluid along the orifice axis and leading to an upstream end of the orifice, and a diffuser element positioned coaxially downstream of the orifice, the diffuser element defining an impingement surface that is at least substantially imperforate in the axial direction and positioned for impingement by a stream of fire-retardant fluid flowing from the orifice in a stream direction along the orifice axis. The impingement surface is shaped to divert fire-retardant fluid in the stream to flow from the orifice axis radially outward, along the impingement surface, towards the region of a peripheral edge of the impingement surface, the impingement surface adapted to substantially redirect the flow of fire-retardant fluid from the stream by at least 90° from the stream direction while maintaining the flow of fire-retardant fluid towards the region of the peripheral edge substantially in contact with the impingement surface in a manner to substantially avoid splashing.

Preferred embodiments of this aspect of the invention may include the following additional feature. The impingement surface is adapted to redirect the flow of fire-retardant fluid by at least 110° from the stream direction while maintaining the flow of fire-retardant fluid towards the region of the peripheral edge substantially in contact with the impingement surface in a manner to substantially avoid splashing.

According to still another aspect of the invention, an upright-type fire protection spray mist nozzle comprises a base defining an orifice, with an orifice axis, through which fire-retardant fluid can flow, an inlet section having an upstream end and defining a conduit for flow of fire-retardant fluid along the orifice axis and leading to an upstream end of the orifice, and a diffuser element positioned coaxially downstream of the orifice. The diffuser element defines an impingement surface that is at least substantially imperforate in the axial direction and positioned for impingement by a stream of fire-retardant fluid flowing from the orifice in a stream direction along the orifice axis, the impingement surface comprising a central conical shape surface region extending generally toward the orifice, with an apex portion disposed along the orifice axis, a peripheral edge disposed generally radially outward from the conical shape surface region, and a concave, toroidal surface region generally between the conical shape surface region and the peripheral edge, the impingement surface being shaped to divert the fire-retardant fluid in the stream to flow from the orifice axis radially outward, along the impingement surface, towards the region of the peripheral edge of the impingement surface, the impingement surface being adapted to redirect the flow of fire-retardant fluid from the stream by at least 90° from the stream direction while maintaining the flow of fire-retardant fluid towards the region of the peripheral edge substantially in contact with the impingement surface in a manner to substantially avoid splashing.

According to still another aspect of the invention, an upright-type fire protection spray mist nozzle comprises a base defining an orifice, with an orifice axis, through which fire-retardant fluid can flow, an inlet section having an upstream end and defining a conduit for flow of fire-retardant fluid along the orifice axis and leading to an upstream end of the orifice, and a diffuser element positioned coaxially downstream of the orifice. The diffuser element defines an impingement surface that is at least substantially imperforate in the axial direction and positioned for impingement by a stream of fire-retardant fluid flowing from the orifice in a stream direction along the orifice axis, the impingement surface comprising a central conical shape surface region extending generally toward the orifice, with an apex portion disposed along the orifice axis, a peripheral edge disposed generally radially outward from the conical shape surface region, and a concave, substantially toroidal or arcuate shaped surface region generally between the conical shape surface region and the peripheral edge, the impingement surface having a shape formed by rotation of an arcuate surface comprised of at least three relatively smoothly blended arcs, rotated about a line defined by the orifice axis passing through the apex, to divert the fire-retardant fluid in the stream to flow from the orifice axis radially outward, along the impingement surface, towards the region of the peripheral edge of the impingement surface, the impingement surface being adapted to redirect the flow of fire-retardant fluid from the stream by at least 90° from the stream direction while maintaining the flow of fire-retardant fluid towards the region of the peripheral edge substantially in contact with the impingement surface in a manner to substantially avoid splashing.

According to another aspect of the invention, an upright-type fire protection spray mist nozzle comprises a base defining an orifice, with an orifice axis, through which fire-retardant fluid can flow, an inlet section having an upstream end and defining a conduit for flow of fire-retardant fluid along the orifice axis and leading to an upstream end of the orifice, and a diffuser element defining an impingement surface that is at least substantially imperforate in an axial direction and positioned for impingement by a stream of fire-retardant fluid flowing from the orifice in a stream direction along the orifice axis, the diffuser element being positioned generally above a horizontal plane through a downstream end of the orifice.

According to another aspect of the invention, an upright-type fire protection spray mist nozzle discharges a spray of fire-retardant fluid over an area to be protected from fire, the spray being characterized by a $Dv_{90}$ droplet size diameter of less than about 250 microns, preferably less than about 200 microns, and more preferably less than about 150 microns, when measured at a pressure of a 175 psi at the inlet to the nozzle, in accordance with the procedure recommended in the 2000 edition of the NFPA 750 Standard on Water Mist Fire Protection Systems, the entire disclosure of which is incorporated herein by reference (also see Section 1–4.5 for the definition of "$Dv_{90}$ droplet size diameter").

According to still another aspect of the invention, an upright-type fire protection spray mist nozzle comprises a

base defining an orifice, with an orifice axis, through which fire-retardant fluid can flow; and an inlet section having an upstream end and defining a conduit for flow of fire-retardant fluid along the orifice axis and leading to an upstream end of the orifice. A diffuser element defines an impingement surface that is at least substantially imperforate in the axial direction and positioned for impingement by a stream of fire-retardant fluid flowing from the orifice in a stream direction along the orifice axis, the diffuser element being positioned generally above a horizontal plane through a downstream end of orifice, and the orifice has an orifice diameter preferably less than about 0.200 inch, and more preferably less than about 0.150 inch, and still more preferably less than about 0.110 inch.

The invention provides, in its broadest aspect, an upright-type fire protection spray mist nozzle, and further provides a diffuser for an impingement-type nozzle having a solid (i.e., at least substantially imperforate in an axial direction), three-dimensional surface shaped to receive and redirect a coherent fluid stream impinged thereupon with substantially no splashing, even when the primary axis of the fluid stream at impact is essentially completely opposed by the impingement surface. Furthermore, surface discontinuities defined by the impingement surface discretely divide the impinging fluid stream into multiple segments with little energy loss, even at low velocities, and selected segments can be essentially reversed in direction with respect to the initial stream flow direction from the nozzle outlet. Additionally, the resulting spray pattern discharge consists of water droplets that appear to be substantially smaller than those typically associated with impingement-type diffusers, even those with smaller orifices. For example, with a fluid (water) pressure of about 175 psi at the inlet section of the mist nozzle of this invention having an orifice diameter of about 0.106 inch, the nozzle discharges a spray with a $Dv_{90}$ droplet size diameter of less than about 200 microns, as compared to a $Dv_{90}$ droplet size diameter of the order of 300 microns for the Grinnell Type AM4 AquaMist® pendent-type nozzle having a nominal orifice diameter of 0.091 inch, as described in Grinnell Technical Data Sheet TD1173, when measured in accordance with the procedure recommended in the 2000 Edition of the NFPA 750 Standard on Water Mist Fire Protection Systems.

The required spray pattern characteristics of mist nozzles, including droplet size and droplet count density, for use in fixed spray fire fighting systems are determined by the expected fire scenario. Of particular interest is redirection of a majority of the discharged water downstream of the impingement surface of the diffuser in a direction nominally opposite to the direction of bulk flow of the water stream, upstream of the impingement surface of the diffuser, while maintaining relatively small droplet size within the nozzle spray pattern. The attribute of maintaining small droplet size while reversing the bulk average direction of the fluid flow allows spray pattern characteristics not previously achieved using existing technology.

The present invention provides a nozzle that can be employed to distribute a water mist discharge pattern that is discretely adjustable, allowing predetermined positioning of a multitude of areas of high and low water discharge density as deemed preferable for an expected fire scenario. The result is an improvement in performance over existing impingement-type water mist diffusers.

The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

## DESCRIPTION OF DRAWINGS

FIG. 1 is a front elevational view of an upright fire protection spray mist nozzle of the invention, while FIG. 1A is a cross-sectional view of an arm, taken at the line 1A—1A of FIG. 1; and

FIG. 2 is side elevational view, taken in section at the line 2—2 of FIG. 1, of the upright fire spray mist nozzle of FIG. 1.

FIG. 3 is an enlarged front elevational view of the diffuser element of the upright fire protection spray mist nozzle of FIG. 1.

FIG. 4 is an enlarged bottom elevational view, taken at the line 4—4 of FIG. 3, of the diffuser element of the upright fire spray mist nozzle of FIG. 1;

FIG. 5 is an enlarged side sectional view, taken at the line 5—5 of FIG. 4, of the diffuser element of FIGS. 3 and 4; and

FIG. 6 is a much enlarged side elevational view of a blank for forming the diffuser element of FIGS. 3, 4 and 5, prior to formation of the set of surface discontinuities or notches.

FIGS. 7 and 8 are somewhat diagrammatic, enlarged front and side views, respectively, both taken in section, of the upright fire spray mist nozzle of the invention, and

FIG. 9 is a somewhat diagrammatic front elevational view, also taken in section, of the diffuser element, all showing fluid flowing from the orifice onto the diffuser element surface, where it is redirected by more than 90° substantially without splash, by remaining generally in contact with the diffuser surface until reaching the region of the peripheral edge.

FIG. 10 is a front elevational view of another embodiment of an upright fire protection spray mist nozzle of the invention, for use in an automatic fire protection system; and

FIG. 11 is an enlarged perspective view of another embodiment of a diffuser element for an upright-type fire protection spray mist nozzle of the invention.

Like reference symbols in the various drawings indicate like elements.

## DETAILED DESCRIPTION

Referring to FIGS. 1, 1A and 2, an upright-type fire spray mist nozzle 10 of the invention has a base 12 defining external threads 14 for threaded, sealed connection to a fire retardant fluid supply system (not shown). The base 12 defines a through passageway 16 extending generally along axis, A, for flow of fire retardant fluid from the inlet 18 (in communication with the fluid supply system) to the outlet 20, exterior of the base. In a region downstream of the outlet, arms 22, 24 extend from the base 12 to an apex 26, positioned downstream of, and coaxial with, an orifice 28 defined by an orifice insert 30 and continuous with passageway 16 of the base 12, e.g. in much the same way as in traditional nozzles typically used for fire protection system service.

A strainer 32 positioned across the inlet 18 to passageway 16 protects orifice 28 in orifice insert 30 from clogging, e.g., due to debris in the fluid supply system. Under standby conditions, an elastomeric plug (not shown) may be employed to seal the outlet 20 from airborne debris, insects and the like that might tend to clog the orifice, with a flexible lead (not shown), e.g. of metal or plastic, attaching the plug to the base 12 of the nozzle so that the plug will not be blown away from the nozzle upon discharge of fluid from the nozzle outlet.

Referring now also to FIGS. 3, 4 and 5, in the fire protection nozzle 10 of the invention, a diffuser 40 defining

a solid (i.e., at least substantially imperforate in the axial direction) impingement surface **42** opposed to flow of fire retardant fluid from the orifice **28** is mounted to the apex **26**, e.g., in threaded engagement therewith, to allow adjustment of the spacing of the impingement surface **42** from the orifice **28** and to allow rotational positioning of discontinuities (notches) **56** defined in the region of the peripheral edge **50**.

Referring also to FIG. **6**, the impingement surface **42** of the diffuser **40** for redirecting the water flow from the orifice **28** of the nozzle outlet **20** (FIGS. 1 and 2) is preferably defined by a solid, hemispherical shaped body **44**, formed, e.g., by machining, sintering, investment casting or other suitable process, of brass, or other suitable material. The impingement surface includes a protruding, generally conical shape surface region **46** with an apex **48** centered generally on axis, A, and extending relatively toward the orifice **28**. Surrounding the conical shape region **46**, inward from the peripheral edge **50** of the impingement surface **42**, is a substantially toroidal or arcuate shape, concave surface region **52**, which is recessed, relative to the orifice **28**, from the a plane, $H_P$, of the apex **48** and peripheral edge **50**. In a preferred embodiment, the shape of the concave region **52** is defined by rotating an arcuate surface, E, comprised of three or more arcs of relatively smoothly blended radii, around axis, A, of the hemispherical shaped body **44**. By way of example, in one preferred embodiment, for a diffuser **40** of the invention having a diameter, $D_D$, of 1.00 inch, the arcuate surface, E, may be formed by five relatively smoothly blended arcs, $E_1$, $E_2$, $E_3$, $E_4$, $E_5$, e.g., having radii of $R_1$, $R_2$, $R_3$, $R_4$, $R_5$, of about 0.169 inch, 0.120 inch, 0.655 inch, 0.120 inch, and 0.195 inch, respectively, where the center point of $R_1$ is spaced about 0.117 inch from axis, A, and about 0.039 inch upstream from plane $H_P$, the center point of $R_2$ is spaced about 0.153 inch from axis, A, and about 0.072 inch upstream from plane $H_P$, the center point of $R_3$ is spaced about 0.234 inch from axis, A, and about 0.561 inch upstream from plane $H_P$, the center point of $R_4$ is spaced about 0.314 inch from axis, A, and about 0.104 inch upstream from plane $H_P$, and the center point of $R_5$ is spaced about 0.351 inch from axis, A, and about 0.038 inch upstream from plane $H_P$. Preferably, the impingement surface **42** defines a set of discontinuities formed in the region of the outer peripheral edge, with the number, size and shape of the discontinuities determining the precise spray discharge pattern. For example, in the diffuser **40** shown in FIGS. **3–5**, the set of discontinuities has the form of a set of notch surfaces **56**, e.g., at least about eight notches, preferably at least about 16 notches, and more preferably at least about 32 notches, In the presently preferred embodiment, as described and shown, the set of discontinuities has the form of a set of 48 notches, each having width, $N_W$, at the peripheral edge **50**, e.g., about 0.030 inch, evenly spaced, e.g., at about 7.5°, about the periphery of the diffuser **40**, separated by tines **70**, each having width, $T_W$, at the peripheral edge **50**, e.g., about 0.035 inch. It has been found that increasing the number of discontinuities or notches, e.g., beyond the eight notches of the diffuser described in the parent to this application (U.S. application Ser. No. 09/603,686, filed Jun. 26, 2000), results in an advantageous decrease in the size of droplets dispersed from the diffuser by creating more surfaces for breakup of the flow. The notch surfaces **56** have smoothly-curved base regions **57** of radii, $R_N$, e.g., about 0.015 inch, extending along and outwards from a plane, $C_P$, tangent to the base surface **60** of the concave surface region **52** and extending through the peripheral edge region **50** of the impingement surface **42** and generally parallel to the face plane, $H_P$, and lateral surfaces that, in a preferred embodiment, are formed, e.g., with an end mill moved radially outward. The peripheral edge **50** of the diffuser **40** has an inner edge diameter, $D_I$, measured in the face plane, $H_P$, which defines the peripheral edge. In one preferred embodiment, the inner edge diameter, $D_I$, is about 0.959 inch.

Referring to FIGS. **7** and **8**, and, in particular, FIG. **9**, the bulk (stream) direction of the water flow (arrow, F) striking upon the conical shape region **46** of the impingement surface **42** at the apex **48** initially remains predominantly in the same direction as the water stream, W. Thereafter, as the water flows over the surface of the conical shape region **46** and then relatively outward from the orifice axis, A, over the impingement surface **42**, the depth or local thickness of the water is decreased. The bulk flow direction of water flowing radially outward (relative to the orifice axis, A) over the conical shape region **46** of the impingement surface **42** is gradually turned (arrow, L) and then reversed (arrow, M) relative to the direction of the impacting water stream (arrow, F) as the fluid passes from the initial point of impingement, I, upon the apex **48** of the conical shape region **46** of the impingement surface **42** and traverses over the concave inner surface region **52**, towards the region of the peripheral edge **50**. The resulting thinning layer of water is then broken into discrete segments $N_1$, $N_2$ (interconnected, at least initially, by water sheet, O, therebetween) to provide a predetermined droplet distribution pattern by the placement of a set of protruding obstructions or discontinuities, such as a set of notches **56**, or a set of ridges, passageways, or the like, upon the impingement surface **42**. The condition of the discharge stream, W, impinging on the impingement surface **42** of the diffuser **40** is preferably a steady, well-defined, pencil-like stream, free from excessive expansion, turbulences, and distortions. The orifice geometry attributes that produce such a discharge stream have previously been described in Fischer U.S. Pat. No. 5,392,993 and in Fischer U.S. Pat. No. 5,505,383, the complete disclosures of which are incorporated herein by reference. A steady, coherent discharge stream, W, produces a relatively more stable, uniform spray pattern from the impingement surface **42** of the diffuser **40**, while a discharge stream that is unstable or distorted can typically result in a less stable or skewed spray pattern. It is noted also that the initial direction of fluid flow (arrow, F) from the discharge orifice **28** of the nozzle of the invention is oriented away from the object to be protected, with the impingement surface **42** of the diffuser **40** of the invention reversing the direction of flow so that the fire-fighting agent is discharged back towards the hazard area. In preferred embodiments of the invention, the impingement surface **42** of the diffuser **40** redirects the water flow from the discharge orifice while minimizing the introduction of turbulence prior to water stream breakup. This is preferable, as the introduction of turbulence tends to reduce the efficiency of the water droplet generation, resulting in an increase in mean droplet diameter and ultimately a decrease in fire fighting efficiency and effectiveness. A diffuser that does not cause the water to splash is inherently more efficient because the energy otherwise lost to splashing is instead used either to obtain a reduction in droplet size or to maximize droplet momentum. Also, as the diameter of the impingement stream is expanded and the resulting depth as it flows radially outward over the impingement surface is decreased, the water sheet becomes thinner, and it is apparent that the thinner the water sheet achieved prior to break-up, the smaller the droplets (mist) that will be formed upon break-up.

Referring again to FIG. **9**, the operation of the diffuser element **40** of the invention, as it is presently understood, will now be described (for clarity, and to facilitate understanding, only the notches **56** of discontinuities in the sectional plane are represented in this drawing). The water stream, W, from the discharge orifice **28** impinges upon the impingement surface **42** of the diffuser **40** at the apex **48** of the generally conical shape surface **46** generally centered on axis, A, and extending relatively toward the orifice **28**. The bulk direction of the water flow stream striking the impingement surface **42** initially remains predominantly in the same direction as the water stream. However, as the water flows over the conical shape surface **46** (arrow, L), the increasing diameter of the conical surface towards its base reduces the depth or local thickness of the water flowing relatively outward from the orifice axis, A, over the impingement surface **42**. The bulk flow direction of water flowing over the impingement surface **42** is gradually turned radially outward (arrow, L), relative to the orifice axis, A, and then reversed (arrow, M), relative to the direction (arrow, F) of the impacting water stream as the fluid passes from the initial point of impingement (apex **48**) upon the impingement surface **42** and traverses over the concave inner surface region **52**, towards the region of the peripheral edge **50**. The resulting layer of water, as it is thinned, stretches until the surface tension is overcome and droplets are formed, to be delivered in a predetermined droplet distribution pattern by the placement of discontinuities, such as notches **56** (as shown), slots, ridges, passageways, and other protruding obstructions or discontinuities upon the impingement surface **42**.

In preferred embodiments, the diameter, $D_C$, at which the tangent plane, $C_P$, of the internal concave surface **52** is perpendicular to the bulk fluid flow direction (axis, A, and arrow, F) divided by the diameter of the water stream, $D_W$, as the stream is about to pass through the face plane, $H_P$, is equal to or greater than at least about 2, preferably at least equal to or greater than about 3, and more preferably at least equal to or greater than about 4. A ratio value of less than about 2 can result in the water stream splashing off the diffuser. For example, according to the approximate dimensions of one preferred embodiment:

$D_C$=0.47 inch

$D_W$=0.11 inch

$D_C/D_W$=4.3≧4>>2

Also, it has been found that a ratio of $D_I$ (i.e., inner edge diameter of the peripheral edge of the diffuser element measured in the face plane, $H_P$) to $D_W$ (i.e., stream diameter of the water stream measured as it is about to pass through the face plane, $H_P$) of at least about 3 is preferred. A ratio of at least about 5.5 is more preferred, with a ratio of at least about 8 being still more preferred. Basically, as the water stream is distributed radially outward from the apex of the diffuser surface, the expanding stream is maintained as a continuum (provided that the arcuate surface is relatively smooth and there is no significant splashing of water). As a result, as the water stream moves radially outward, the thickness of the water layer decreases, with a corresponding decrease in the size of the droplets created by the interruption of the flow by the set of discontinuities (notches) towards the region of the peripheral edge of the diffuser. For example, according to the approximate dimensions of one preferred embodiment:

$D_I$0.96 inch

$D_W$=0.11 inch

$D_I/D_W$=8.7 >>3

There are, however, practical limits to the degree to which $D_I$ can be increased, and, furthermore, as $D_I$ is increased, the water flow incurs increased friction loss resulting in lower water droplet velocity as the droplets leave the periphery of the diffuser.

This fundamental shape of the impingement surface **42** of the diffuser of the invention results in an upright-type, water spray mist nozzle **10** providing spray patterns found suitable for fire protection of Class B combustibles, particularly liquid fuels released under elevated pressure from an orifice, as the spray pattern characteristics of upright-type diffusers can be substantially different from those of pendent-type diffusers, and found to meet the fire test requirements of the International Maritime Organization (IMO) MSC/Circ. 913 (Jun. 4, 1999). The spray pattern characteristics of upright-type diffusers of the invention can also be designed to be very similar to those of pendent-type diffusers; the fundamental shape of the upright-type diffusers of the invention provide a relatively greater degree of flexibility in designing spray patterns, e.g., as compared to pendent-type nozzle diffusers. Additionally, upright positioning permitted by the nozzle of the invention advantageously allows a preferred method of installation, as the point of origin of the spray pattern can then be placed at the greatest possible distance (i.e., above) from the protected hazard. This can be of critical importance in situations where the available clearance between surface of the hazard and adjacent surfaces is relatively small. Furthermore, with an upright-type nozzle installation, the pipe to which the fire-fighting nozzle is fitted somewhat protects the nozzle from impact damage, e.g. during placement and removal of material from the region to be protected.

A number of embodiments of the invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. For example, referring to FIG. **10**, in another embodiment, an upright fire protection spray mist nozzle **100** of the invention may be used in an automatically operating fire protection system, with a thermal-responsive release element **102**, e.g. a glass bulb or fusible link, engaged by a bulb seat **103** at the apex of an axially adjustable diffuser element **104** to secure an orifice seal **106** in normal or standby condition. Alternatively, the thermal-responsive release element **102** may be replaced with a device that is remotely actuatable (released) in response to a fire condition determined by a separate fire detector. Also, the apex of the generally conical shape surface region and the peripheral edge of the impingement surface of a diffuser element of the invention may be disposed in different planes, e.g. relatively closer to or more spaced from the orifice. The peripheral edge of the diffuser may also have the form of a toothed surface, with the tips of the respective teeth in the same or different planes.

Also, in some embodiments of upright-type fire protection spray mist nozzles of the invention, it is contemplated that the ratio of $D_I$ (i.e., inner edge diameter of the peripheral edge of the diffuser element measured in the face plane, $H_P$) to $D_W$ (i.e., the stream diameter of the water stream as it is about to pass through the face plane, $H_P$) may be up to about 20, or even higher. Finally, referring to FIG. **11**, a diffuser element **140** of another embodiment of the invention, e.g., as described in the parent to this application (U.S. application

Ser. No. 09/603,686, filed Jun. 20, 2000) has a concave region **152** defined by rotation of an arcuate surface, E', around axis, A', and a set of eight, evenly spaced notches **156**. In this embodiment, the arcuate surface, E', has the shape, e.g., of a regular ellipse, with three arcs of relatively smoothly blended radii.

In addition, in some embodiments of upright-type fire protection spray mist nozzles of the invention, the arcuate surface of the diffuser may be comprised of one or more relatively smoothly blended arcs having a substantially infinite radius (i.e., a straight line), and where an arc having a substantially infinite radius is coplanar with the tangent plane, $C_P$, of the internal concave surface **52**, the diameter, $D_C$, is measured between the centers of the arcs having a substantially infinite radius in the tangent plane, $C_P$, through the axis, A.

Accordingly, other embodiments are within the scope of the following claims.

What is claimed is:

**1**. An upright-type fire protection spray mist nozzle, comprising:

a base defining an orifice, with an orifice axis, through which fire-retardant fluid can flow;

an inlet section having an upstream end and defining a conduit for flow of fire-retardant fluid along said orifice axis and leading to an upstream end of said orifice; and

a diffuser element positioned coaxially downstream of said orifice, said diffuser element defining an impingement surface that is at least substantially imperforate in an axial direction positioned for impingement by a stream of fire-retardant fluid flowing from said orifice in a stream direction along said axis, said impingement surface comprising:

a central conical shape surface region extending generally toward said orifice, with an apex portion disposed along said axis,

a peripheral edge disposed generally radially outward from said conical shape surface region and defining a face plane, and

a concave, substantially toroidal surface region generally between said conical shape surface region and said peripheral edge.

**2**. The upright-type fire protection spray mist nozzle of claim **1**, wherein said apex and said peripheral edge are disposed in a plane generally perpendicular to said axis.

**3**. The upright-type fire protection spray mist nozzle of claim **2**, wherein at least a portion of said toroidal surface region is recessed downstream from said plane of said apex and said peripheral edge, relative to said orifice.

**4**. The upright-type fire protection spray mist nozzle of claim **3**, wherein said substantially toroidal surface region is recessed downstream from said plane of said apex and said peripheral edge, relative to said orifice.

**5**. The upright-type fire protection spray mist nozzle of claim **1**, wherein said stream of fire retardant fluid flowing from said orifice to impinge upon said impingement surface is substantially steady and coherent.

**6**. The upright-type fire protection spray mist nozzle of claim **1**, wherein said concave, substantially toroidal surface region has a shape formed by rotation of an arcuate surface comprised of at least three relatively smoothly blended arcs about a line defined by said orifice axis passing through said apex.

**7**. The upright-type fire protection spray mist nozzle of claim **6**, wherein said arcuate surface is comprised of at least five relatively smoothly blended arcs.

**8**. The upright-type fire protection spray mist nozzle of claim **1**, wherein said impingement surface defines at least one surface discontinuity in a region of said peripheral edge for redirecting a portion of said flow of fire retardant fluid along said impingement surface.

**9**. The upright-type fire protection spray mist nozzle of claim **8**, wherein said impingement surface defines a set of surface discontinuities spaced circumferentially about said axis in said region of said peripheral edge for redirecting at least a portion of said flow of fire retardant fluid along said impingement surface.

**10**. The upright-type fire protection spray mist nozzle of claim **9**, wherein said set of surface discontinuities has the form of a set of notches in said impingement surface.

**11**. The upright-type fire protection spray mist nozzle of claim **10**, wherein said set of notches in said impingement surface defines a set of surface regions extending along and outwards from a plane generally tangent to a base region of said concave surface and lying generally perpendicular to said axis, towards said region of said peripheral edge.

**12**. The upright-type fire protection spray mist nozzle of claim **11**, wherein said set of surface discontinuities comprises a set of at least about 8 notches in said impingement surface.

**13**. The upright-type fire protection spray mist nozzle of claim **12**, wherein said set of surface discontinuities comprises a set of at least about 16 notches in said impingement surface.

**14**. The upright-type fire protection spray mist nozzle of claim **13**, wherein said set of surface discontinuities comprises a set of at least about 32 notches in said impingement surface.

**15**. The upright-type fire protection spray mist nozzle of claim **14**, wherein said set of surface discontinuities comprises a set of at least about 48 notches in said impingement surface.

**16**. The upright-type fire protection spray mist nozzle of any of claims **9–15**, wherein said set of surface discontinuities divides said flow into multiple segments at said peripheral edge with little loss of energy.

**17**. The upright-type fire protection spray mist nozzle of claim **1**, wherein said stream of fire retardant fluid flowing from said orifice has a stream diameter measured as said stream is about to pass through said face plane, and the ratio of a diameter of a region of said concave surface lying generally tangent to a plane that is generally perpendicular to said axis to said stream diameter is greater than or equal to about 2.

**18**. The upright-type fire protection spray mist nozzle of claim **17**, wherein said ratio of a diameter of a region of said concave surface lying generally tangent to a plane that is generally perpendicular to said axis to said stream diameter is greater than or equal to about 3.

**19**. The upright-type fire protection spray mist nozzle of claim **18**, wherein said ratio of a diameter of a region of said concave surface lying generally tangent to a plane that is generally perpendicular to said axis to said stream diameter is greater than or equal to about 4.

**20**. The upright-type fire protection spray mist nozzle of any of claim **1** or claims **10–15**, wherein said peripheral edge has an inner edge diameter measured in said face plane and said stream has a stream diameter measured as said stream is about to pass through said face plane, and a ratio of said inner edge diameter to said stream diameter is at least about 3.

**21**. The upright-type fire protection spray mist nozzle of claim **20**, wherein the ratio of said inner edge diameter to said stream diameter is at least about 5.5.

22. The upright-type fire protection spray mist nozzle of claim 21, wherein the ratio of said inner edge diameter to said stream diameter is at least about 8.

23. The upright-type fire protection spray mist nozzle of claim 22, wherein the ratio of said inner edge diameter to said stream diameter is of the order of about 20.

24. The upright-type fire protection spray mist nozzle of claim 20, wherein said set of surface discontinuities divides said flow into multiple segments at said region of said peripheral edge with little loss of energy.

25. The upright-type fire protection spray mist nozzle of claim 1, in the form of an automatically-operating fire nozzle, further comprises, in a standby condition, a releasable orifice seal secured in position by a thermally-responsive element.

26. An upright-type fire protection spray mist nozzle, comprising:

a base defining an orifice, with an orifice axis, through which fire-retardant fluid can flow;

an inlet section having an upstream end and defining a conduit for flow of fire retardant fluid along said orifice axis and leading to an upstream end of said orifice; and

a diffuser element positioned coaxially downstream of said orifice, said diffuser element defining an impingement surface that is at least substantially imperforate in an axial direction and positioned for impingement by a stream of fire-retardant fluid flowing from said orifice in a stream direction along said axis, said impingement surface including a concave contour shaped to divert fire-retardant fluid in said stream to flow from said axis radially outward, along said impingement surface, towards a region of a peripheral edge of said impingement surface, said impingement surface adapted to substantially redirect said flow of fire retardant fluid from said stream by at least 90° from said stream direction while maintaining said flow of fire-retardant fluid towards said region of said peripheral edge substantially in contact with said impingement surface in a manner to substantially avoid splashing.

27. The upright-type fire protection spray mist nozzle of claim 26, wherein said impingement surface is adapted to redirect said flow of fire-retardant fluid by at least 110° from said stream direction while maintaining said flow of fire-retardant fluid towards said region of said peripheral edge substantially in contact with said impingement surface in a manner to substantially avoid splashing.

28. An upright-type fire protection spray mist nozzle, comprising:

a base defining an orifice, with an orifice axis, through which fire-retardant fluid can flow;

an inlet section having an upstream end and defining a conduit for flow of fire-retardant fluid along said orifice axis and leading to an upstream end of said orifice; and

a diffuser element positioned coaxially downstream of said orifice, said diffuser element defining an impingement surface that is at least substantially imperforate in an axial direction and positioned for impingement by a stream of fire-retardant fluid flowing from said orifice in a stream direction along said axis, said impingement surface comprising a central conical shape surface region extending generally toward said orifice, with an apex portion disposed along said axis, a peripheral edge disposed generally radially outward from said conical shape surface region, and a concave, substantially toroidal surface region generally between said conical shape surface region and said peripheral edge, said impingement surface being shaped to divert fire-retardant fluid in said stream to flow from said axis radially outward, along said impingement surface, towards a region of a peripheral edge of said impingement surface, said impingement surface being adapted to redirect said flow of fire-retardant fluid from said stream by at least 90° from said stream direction while maintaining said flow of fire-retardant fluid towards said region of said peripheral edge substantially in contact with said impingement surface in a manner to substantially avoid splashing.

29. An upright-type fire protection spray mist nozzle, comprising:

a base defining an orifice, with an orifice axis, through which fire-retardant fluid can flow;

an inlet section having an upstream end and defining a conduit for flow of fire-retardant fluid along said orifice axis and leading to an upstream end of said orifice; and

a diffuser element defining an impingement surface that is at least substantially imperforate in an axial direction and positioned for impingement by a stream of fire-retardant fluid flowing from said orifice in a stream direction along said axis, said diffuser element being positioned generally above a horizontal plane through a downstream end of said orifice, and said impingement surface including a concave contour shaped to divert fire-retardant fluid in said stream to flow from said axis radially outward toward a discontinuous peripheral edge to provide a water spray mist having droplets size in accordance with the 2000 edition of the NFPA 750 Standard on Water Mist Fire Protection Systems.

30. An upright-type fire protection spray mist nozzle that discharges a spray of fire-retardant fluid over an area to be protected from fire, said fire protection spray mist nozzle comprising a diffuser element defining a substantially imperforate impingement surface, said impingement surface including a concave contour, and said spray being characterized by a $Dv_{90}$ droplet size diameter of less than about 250 microns when measured at a pressure of a 175 psi at the inlet to the nozzle, in accordance with the procedure recommended in the 2000 edition of the NFPA 750 Standard on Water Mist Fire Protection Systems.

31. The upright-type fire protection spray mist nozzle of claim 30, wherein said spray being characterized by a $Dv_{90}$ droplet size diameter of less than about 200 microns when measured at a pressure of a 175 psi at the inlet to the nozzle, in accordance with the procedure recommended in the 2000 edition of the NFPA 750 Standard of Water Mist Fire Protection Systems.

32. The upright-type fire protection spray mist nozzle of claim 31, wherein said spray being characterized by a $Dv_{90}$ droplet size diameter of less than a bout 150 microns when measured at a pressure of a 175 psi at the inlet to the nozzle, in accordance with the procedure recommended in the 2000 edition of the NFPA 750 Standard on Water Mist Fire Protection Systems.

33. An upright-type fire protection spray mist nozzle, comprising:

a base defining an orifice, with an orifice axis, through which fire-retardant fluid can flow;

an inlet section having an upstream end and defining a conduit for flow of fire-retardant fluid along said orifice axis and leading to an upstream end of said orifice; and

a diffuser element defining an impingement surface that is at least substantially imperforate in an axial direction and positioned for impingement by a stream of fire-

retardant fluid flowing from said orifice in a stream direction along said axis, said impingement surface including a concave contour shaped to divert fire retardant fluid in said stream to flow from said axis radially outward;

said diffuser element being positioned generally above a horizontal plane passing through a downstream end of said orifice; and

said orifice having an orifice diameter preferably less than about 0.200 inch.

**34**. The upright-type fire protection sprinkler of claim **33**, wherein said orifice diameter is less than about 0.150 inch.

**35**. The upright-type fire protection sprinkler of claim **34**, wherein said orifice diameter is less than about 0.110 inch.

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US006059044A

# United States Patent [19]

**Fischer**

[11] **Patent Number: 6,059,044**

[45] **Date of Patent: May 9, 2000**

[54] **FIRE PROTECTION SPRINKLER AND DEFLECTOR**

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[21] Appl. No.: **09/134,493**

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[51] **Int. Cl.**[7] .......... **A62C 37/08**

[52] **U.S. Cl.** .......... **169/37**; 169/39; 239/498; 239/518

[58] **Field of Search** .......... 169/37–41; 239/501, 239/502, 504, 524, 518, 522, 498

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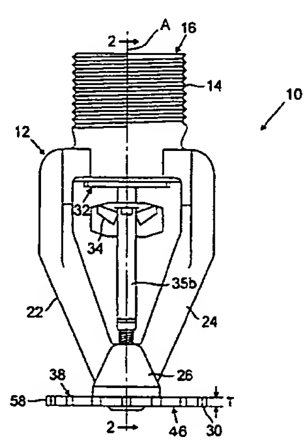
[57] **ABSTRACT**

A pendent-type fire protection sprinkler for forming a superimposed combination of an inner, downwardly-directed spray pattern and an outer, umbrella-shaped spray pattern. The pendent-type sprinkler has a body defining an orifice and outlet for flow of fluid from a source and a pair of frame arms extending from the body. The deflector includes a generally plate-like body member defining reentrant slots, which may include a second type of reentrant slots in addition to a first type of reentrant slots, with slots of the second type positioned symmetrically between adjacent slots of the first type. The length of slots of the second type, measured along the slot centerlines extending inwardly from a peripheral edge of the deflector body member generally toward the central axis of the deflector body, being less than the length of slots of the first type. The second type of reentrant slots provides an additional intermediate componentized spray pattern positioned radially between the inner, downwardly-directed spray pattern and the outer, umbrella-shaped spray pattern.

**98 Claims, 9 Drawing Sheets**



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Color photocopies of five color photographs of Grinnell Corporation "Jumbo A automatic sprinkler—1 1/4" orifice, (labeled Jun. 1995) (2 pp.).

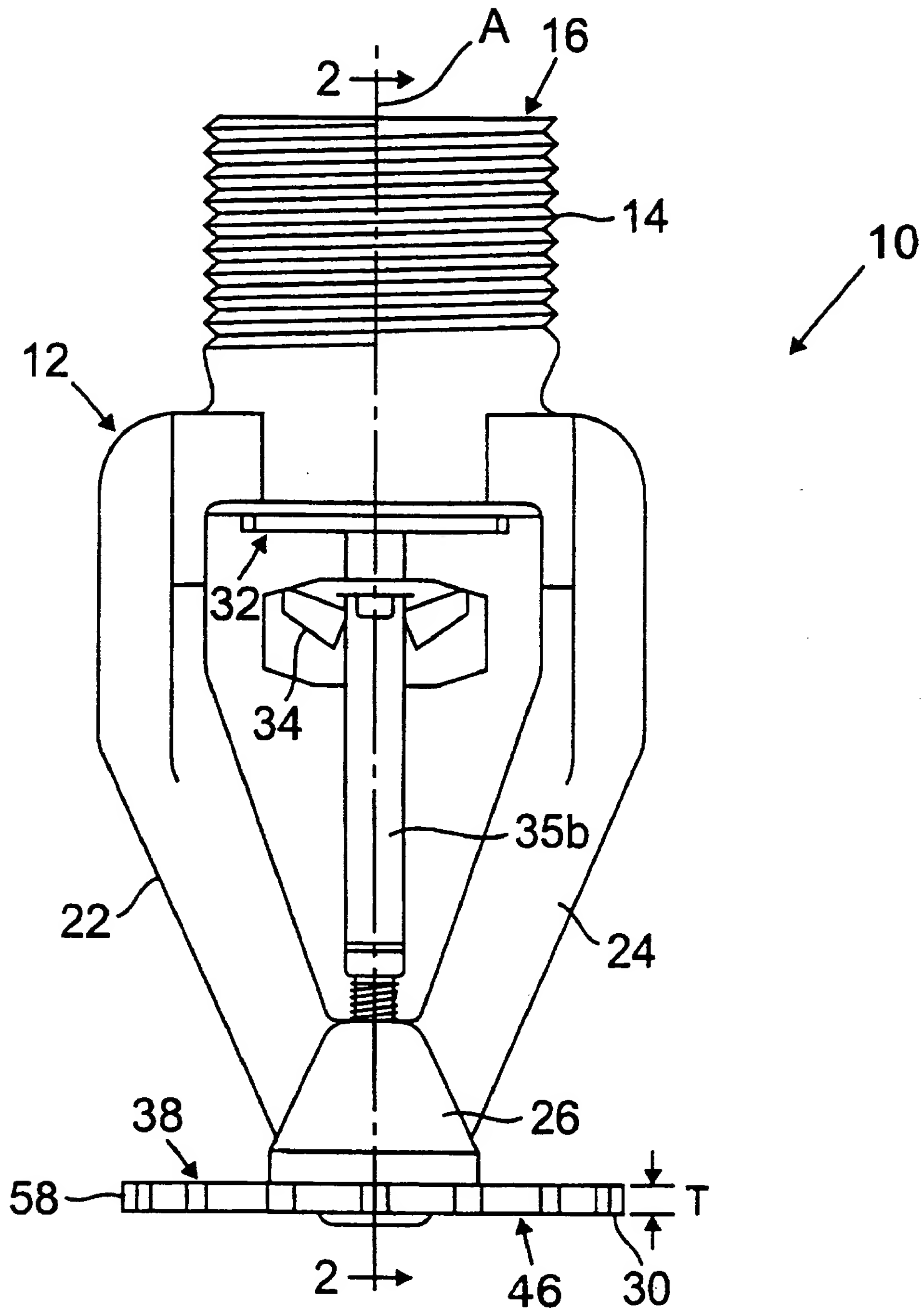



FIG. 1

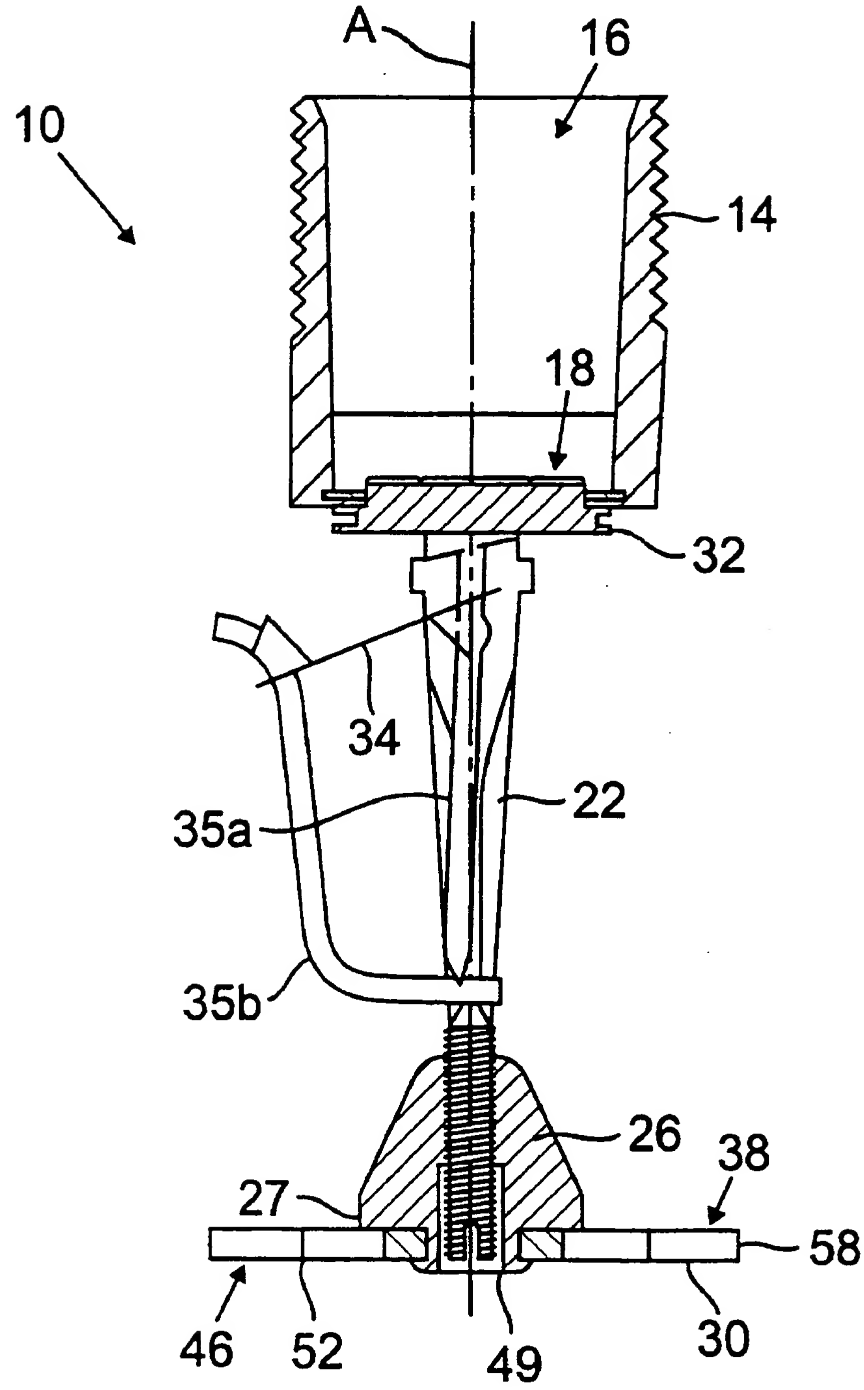



FIG. 2

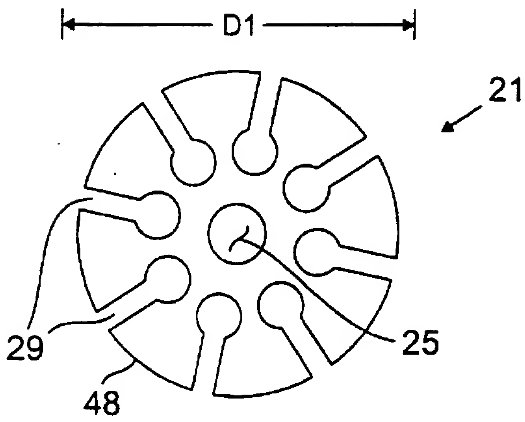



FIG. 3

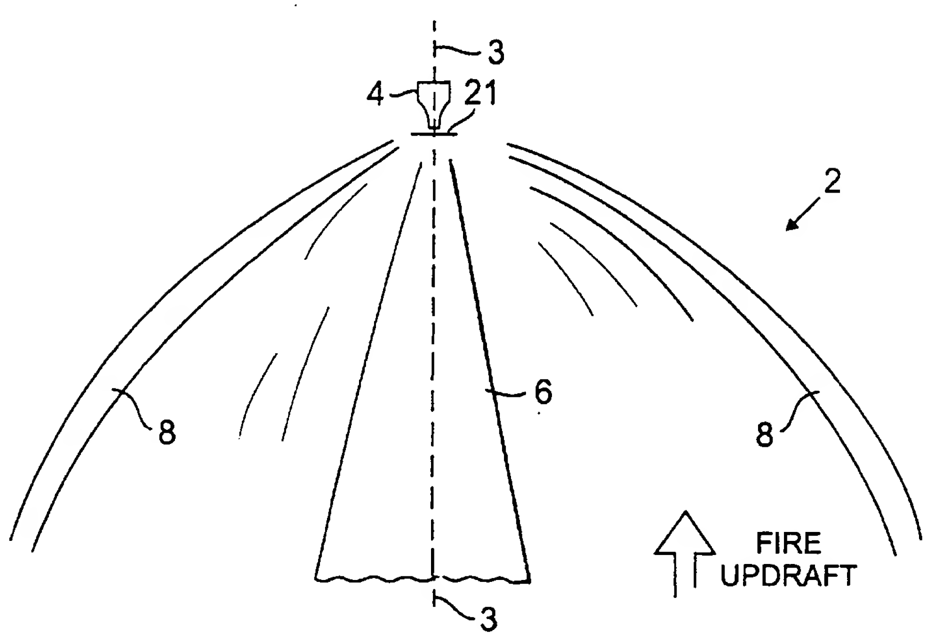



FIG. 4

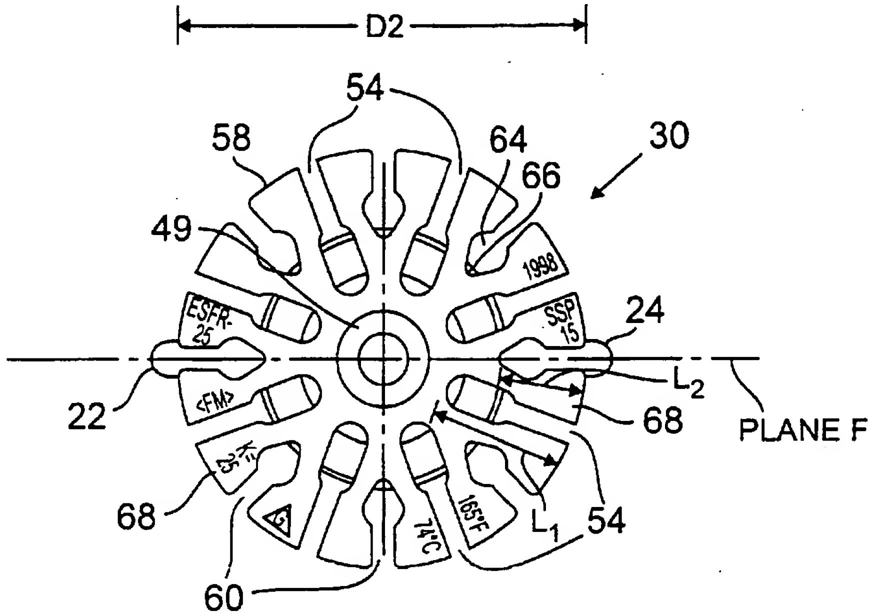

D2
54
58
64
30
66
49
1998
ESFR-25
SSP 15
24
22
<FM>
L2
68
PLANE F
K=25
68
74°C
165°F
L1
54
60

FIG. 5

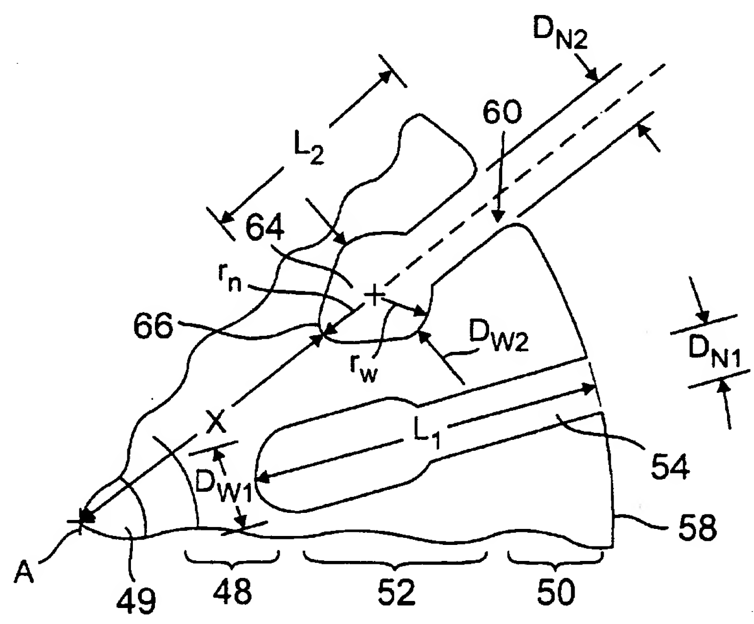

DN2
L2
60
64
rn
66
rw
DW2
DN1
X
L1
54
DW1
58
A
49
48
52
50

FIG. 5A

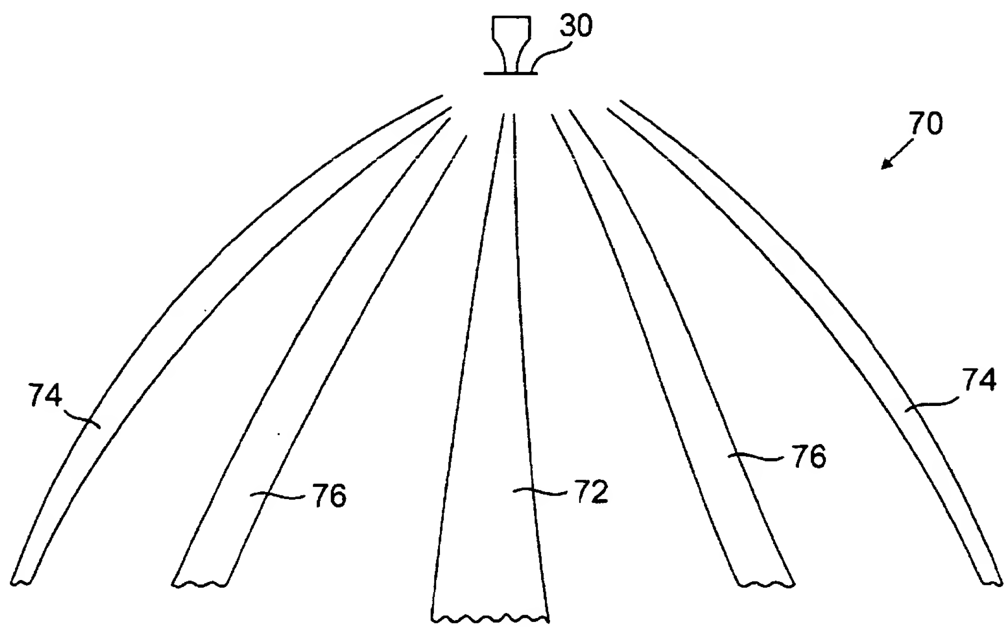



FIG. 6

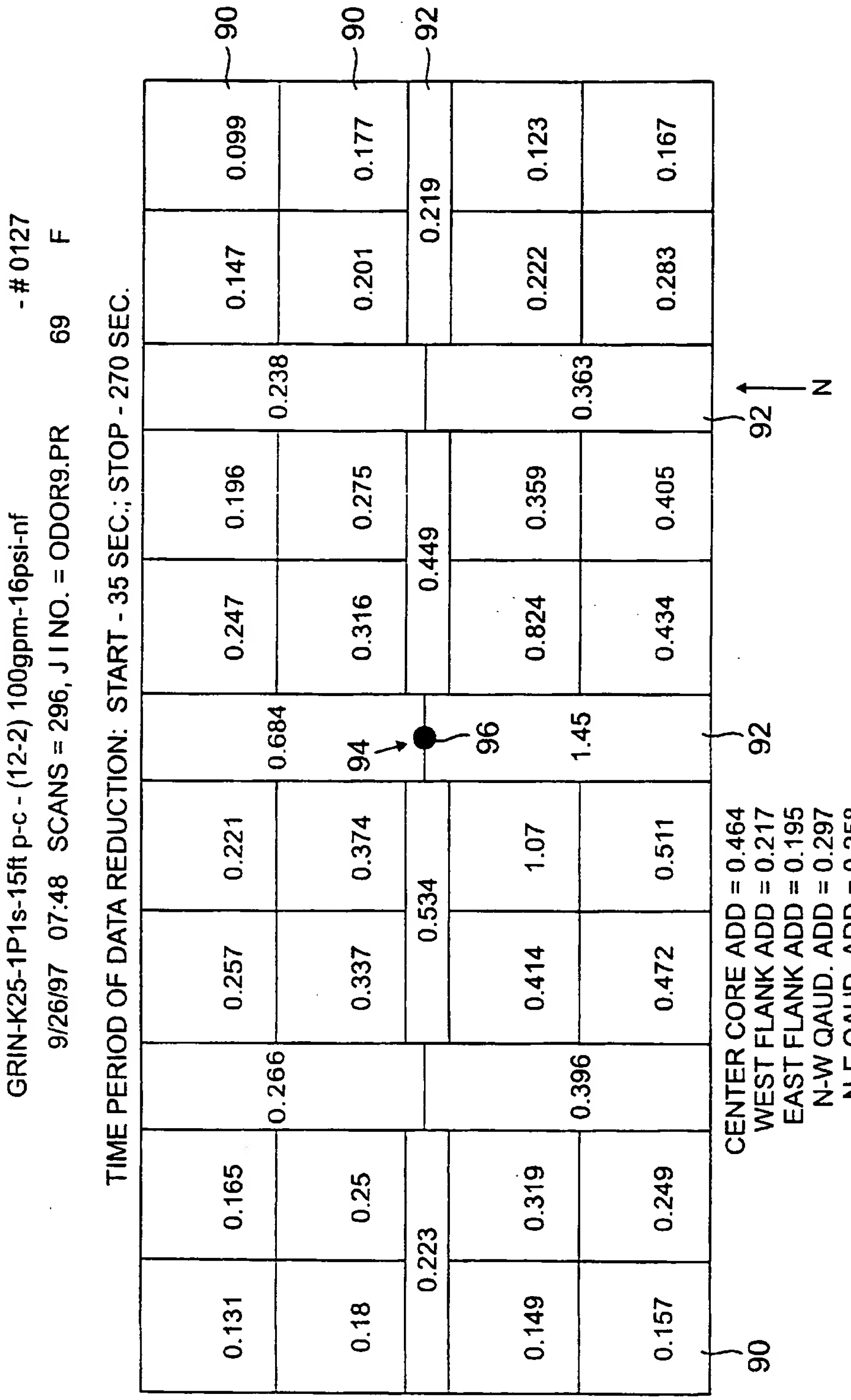



FIG. 7
PRIOR ART

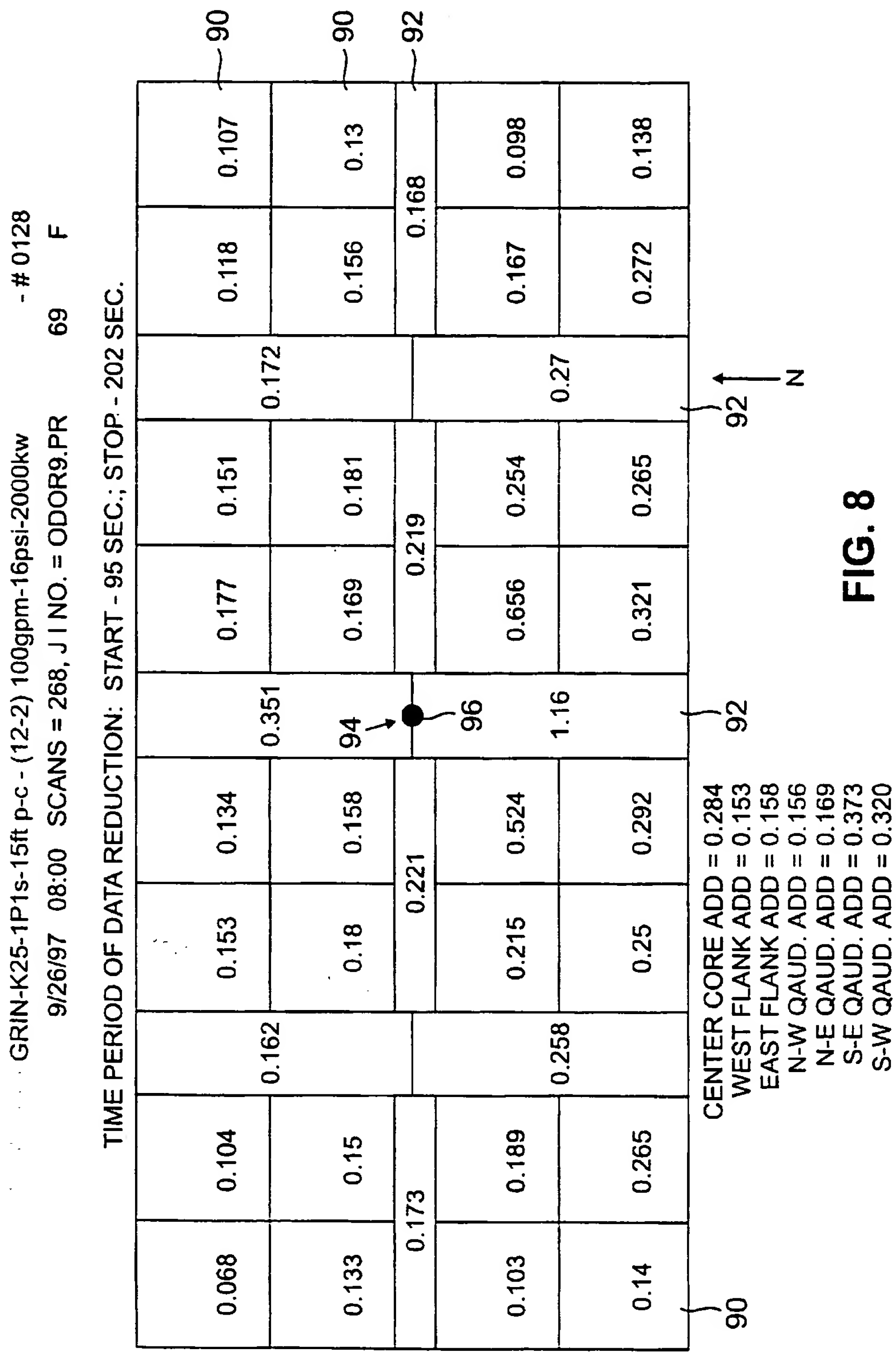



**FIG. 8**
**PRIOR ART**

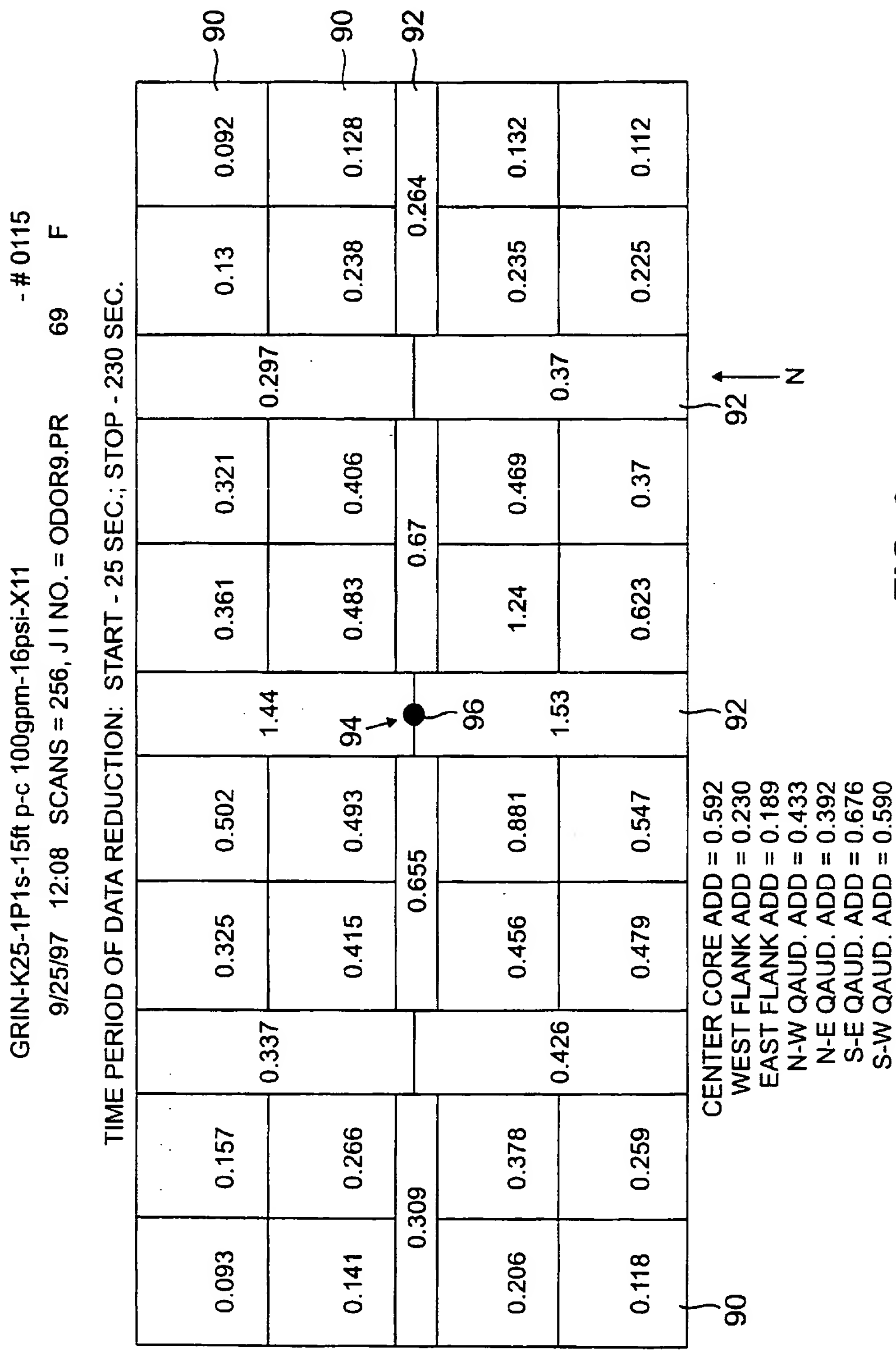
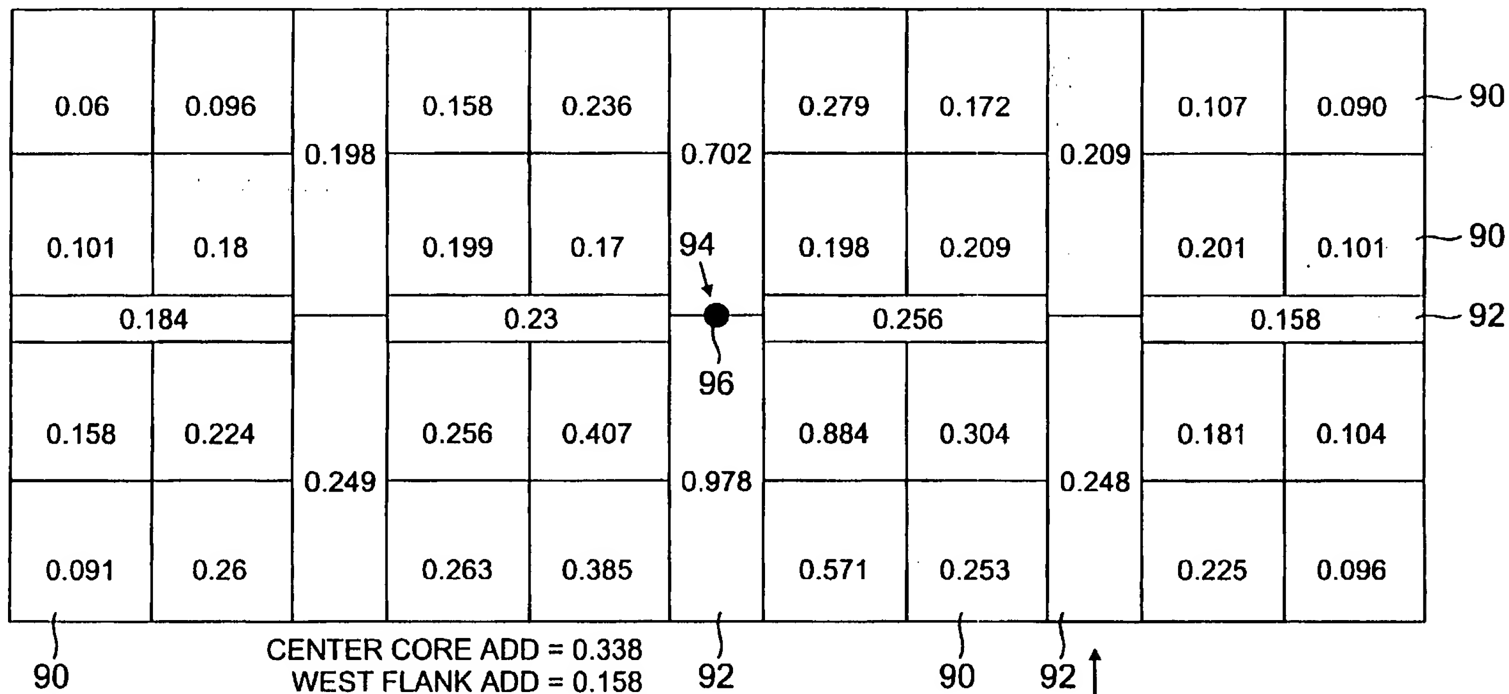

GRIN-K25-1P1s-15ft p-c 100gpm-16psi-X11
- # 0115
9/25/97 12:08 SCANS = 256, J I NO. = ODOR9.PR 69 F
TIME PERIOD OF DATA REDUCTION: START - 25 SEC.; STOP - 230 SEC.
90
90
92
0.093
0.157
0.325
0.502
0.361
0.321
0.13
0.092
0.337
1.44
0.297
0.141
0.266
0.415
0.493
0.483
0.406
0.238
0.128
0.309
0.655
94
96
0.67
0.264
0.206
0.378
0.456
0.881
1.24
0.469
0.235
0.132
0.426
1.53
0.37
0.118
0.259
0.479
0.547
0.623
0.37
0.225
0.112
90
92
92
N
CENTER CORE ADD = 0.592
WEST FLANK ADD = 0.230
EAST FLANK ADD = 0.189
N-W QAUD. ADD = 0.433
N-E QAUD. ADD = 0.392
S-E QAUD. ADD = 0.676
S-W QAUD. ADD = 0.590

FIG. 9

GRIN-K25-1P1s-15ft p-c - 100gpm-16psi-2000kw-X11 - # 0116

9/25/97 13:05 SCANS = 386, J I NO. = ODOR9.PR 69 F

TIME PERIOD OF DATA REDUCTION: START - 65 SEC.; STOP - 350 SEC.




CENTER CORE ADD = 0.338
WEST FLANK ADD = 0.158
EAST FLANK ADD = 0.150
N-W QAUD. ADD = 0.190
N-E QAUD. ADD = 0.214
S-E QAUD. ADD = 0.503
S-W QAUD. ADD = 0.327

FIG. 10

# FIRE PROTECTION SPRINKLER AND DEFLECTOR

## CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. Ser. No. 09/079,789, filed May 15, 1998, which is now abandoned.

The invention relates to deflectors and fire protection sprinklers which utilize such deflectors.

## BACKGROUND OF THE INVENTION

Fire protection sprinklers may be operated individually, e.g. by a self-contained thermally sensitive element, or as part of a deluge system in which fire retardant fluid flows through a number of open sprinklers, essentially simultaneously. Fire retardant fluids may include natural water or appropriate mixtures of natural water and one or more additives to enhance fire fighting properties of a fire protection system.

Fire protection sprinklers generally include a body with an outlet, an inlet connectable to a source of fire retardant fluid under pressure, and a deflector supported by the body in a position opposing the outlet for distribution of the fire retardant fluid over a predetermined area to be protected from fire. Individual fire protection sprinklers may be automatically or non-automatically operating. In the case of automatically operating fire protection sprinklers, the outlet is typically secured in the normally closed or sealed position by a cap. The cap is held in place by a thermally-sensitive element which is released when its temperature is elevated to within a prescribed range, e.g. by the heat from a fire. The outlets of non-automatic sprinklers are maintained normally open, and such sprinklers are operated in an array, as part of a deluge system, from which fire retardant fluid flows when an automatic fluid control valve is activated by a separate fire, e.g. heat, detection system.

Installation or mounting position is another parameter which distinguishes different types of fire protection sprinklers. For example: Pounder U.S. Pat. No. 4,580,729 illustrates a pendent mounting (i.e., pendent-type) sprinkler arranged so that the fluid stream discharged from the outlet is directed initially downwards against the deflector; Dukes U.S. Pat. No. 2,862,565 illustrates an upright mounting (i.e., upright-type) sprinkler arranged so that the fluid stream discharged from the outlet is directed initially upwards against the deflector; and Mears U.S. Pat. No. 4,296,815 and Fischer U.S. Pat. No. 4,296,816 illustrate a horizontal mounting (i.e., horizontal-type) sprinkler arranged so that the fluid stream discharged from the outlet is directed initially horizontally against the deflector. In each case, the purpose of the deflector is to break up the fluid stream into a pattern of spray that can suitably cover the area to be protected by the sprinkler from fire.

ESFR (Early Suppression Fast Response) fire protection sprinkler applications have typically required the use of pendent sprinklers. Upright and horizontal sprinklers have generally been found less suitable for ESFR applications, particularly at commodity storage heights of greater than 30 feet. This is because upright sprinklers inherently have reduced downward spray directly beneath the sprinklers and, therefore, underneath the fire protection fluid supply piping from which they are fed. Horizontal type sprinklers, on the other hand, are generally designed with a spray pattern that projects horizontally to protect more remote reaches of the intended coverage area and, as such, do not provide the downward thrust of fluid spray necessary for ESFR sprinkler applications, over the entire area to be protected from fire by the sprinkler.



The concept underlying ESFR sprinkler technology is that of delivering onto a fire at an early stage a quantity of water sufficient to suppress the fire before a severe challenge can develop. ESFR sprinklers are particularly useful in commercial settings where the clearance between the sprinklers and the source of the fire could be large. For example, in a warehouse having high ceilings, the distance between pendent sprinklers and the upper surfaces of combustible commodities in the storage racks can be relatively large. In such settings, the size of a fire can grow significantly before a first sprinkler is activated by heat from the fire. Thus, it was recognized that to suppress a fire in such a setting, a greater quantity of water should be delivered quickly so that the fire will be kept less intense, and the corresponding convective heat release rate will be kept lower. In turn, with a lower heat release rate, the upward plume velocity of the fire will also be relatively lower. Fire protection specialists often characterize this concept by saying that the Actual Delivered Density (ADD) of the first operating sprinklers) should exceed the Required Delivered Density (RDD). RDD is defined as the actual density of fire retardant fluid required to suppress a fire in a particular combustible commodity in units of gpm/ft$^2$. ADD is generally defined as the density at which water is actually deposited from operating sprinklers onto the top horizontal surface of a burning combustible array, in units of gpm/ft$^2$.

The relationships between sprinkler spray patterns, fire plume velocity, and amount of combustible commodity are important factors which need to be taken into account in the design of ESFR sprinklers. As the ceiling-to-floor distance increases and the amount of combustible commodity increases, the fire plume velocity and upward thrust increase to such vigorous levels that standardized tests now require actual opposing thrust specifications in the central area of the spray pattern for certification of an automatic fire protection sprinkler for service in the ESFR sprinkler category (Ref. Underwriters Laboratories (UL) and Factory Mutual (FM) ESFR Sprinkler Standards). Previous approaches for addressing higher elevation, higher challenge fire protection applications with ESFR pendent sprinklers have included using deflectors with straight slots or slots that taper to become slightly wider in the radially outward direction; in combination with, increasing fluid water pressure to compensate for increased elevations, since the thrust of the spray pattern is a combination of both velocity and mass of the fire retardant fluid droplets.

ESFR pendent sprinklers often provide a sprinkler spray pattern having a central downward thrusting core formation. Providing a central core of high thrust droplets is particularly important in higher elevation, higher challenge fire protection applications where the updraft of a quickly developing fire located under a sprinkler head could fully displace the spray pattern of the sprinkler head if the downward thrust was insufficient to effectively oppose the updraft. One approach for providing more water coaxial with the centerline of the sprinkler spray pattern is described in Mears U.S. Pat. No. 4,296,815, the entire disclosure of which is incorporated herein by reference. Mears '815 describes a horizontal sidewall sprinkler with a discharge which increases the amount of fire protection fluid in the region coaxial with the sprinkler discharge axis by use of a deflector with radially extending tines spaced by reentrant slots. A reentrant slot is defined as a cutout extending through a deflector and generally radially inwardly from an opening at the deflector periphery, the slot having a transverse width which is larger at a more radially inward portion of the deflector than the transverse width nearer the peripheral region of the deflector.

## SUMMARY OF THE INVENTION

The invention relates to a pendent-type fire protection sprinkler of the type including a sprinkler body defining an orifice and an outlet for delivering a flow of fluid from a source, and at least one arm extending from the sprinkler body. The orifice defines an orifice axis, and the outlet is disposed generally coaxial with the orifice axis. The sprinkler also includes an apex element supported by the at least one arm, with an apex axis generally coaxial with the orifice axis, and a deflector mounted to the apex element at a distance further from the outlet than the apex element.

In a general aspect of the invention, the deflector of the sprinkler includes a deflector body defining a first, inside surface opposed to the flow of fluid, an opposite, second surface, and a deflector axis generally coaxial with the orifice axis. The deflector body defines two or more generally opposing reentrant slots extending through the deflector body, from the first, inside surface to the second, outside surface, with the slot openings at an outer peripheral edge of the deflector body. The reentrant slots extend inwardly from the peripheral edge, along reentrant slot centerlines or axes, generally toward the deflector axis. The reentrant slots also have first widths measured transverse to the slot centerlines in regions of the peripheral edge and second widths measured transverse to the slot centerlines at a regions spaced inwardly, toward the deflector axis, relative to the regions of the peripheral edge, the second widths being greater than the first widths. The innermost portions of the reentrant slots extend inwardly toward the deflector axis so as to be no further outward from the deflector axis than the outermost surface of the apex element.

The portion of the deflector between the slot portion extending inward from the periphery of the deflector and the larger width opening at the radially more inward portion of the deflector provides a web-like component spray pattern extending outward from the central core formation.

The pendent-type fire protection sprinkler of the invention is a fixed deflector, impingement-type fire protection sprinkler in which the body defines an inlet for connection to a source of fluid under pressure, an outlet, and an orifice normally located just upstream of the outlet. The outlet may be normally closed by a plug held in place by a thermally responsive element configured to automatically release the plug when the temperature of the thermally responsive element is elevated to within a prescribed range. Upon operation (i.e., release of the plug), with the fire protection sprinkler of the invention, whether individually operated or used open as part of a local application or total flooding system, a vertically directed, relatively coherent, single stream of water (downward for pendent-type sprinklers) rushes through the outlet, from the orifice, towards the deflector. As it impacts (i.e., impinges) upon the deflector, the water is diverted generally radially downward and outward, breaking up into a spray pattern, the configuration of which, in large part, is a function of the deflector design, and it is projected over the intended area of coverage, i.e., the protected area.

The flow rate "Q" from a sprinkler of the invention, in which a single stream of water is discharged from the outlet orifice, expressed in U.S. gallons per minute (gpm), is determined by the formula:

$$Q=K(p)^{1/2}$$

where: "K" represents the nominal nozzle discharge coefficient (normally referred to as K-factor), and gape represents the residual (flowing) pressure at the inlet to the nozzle in pounds per square inch (psi).

The fire protection sprinkler of the invention operates by impacting a relatively coherent, single fluid jet against the deflector described above. The fire protection sprinkler has a K-factor preferably in a range of from about 8.0 to 50.0, more preferably in the range of about 14.0 to about 30.0, and most preferably about 25.0, the range from about 14.0 to 30.0 being found more preferable from the standpoint of minimizing fire protection system installation costs and operating power requirements.

Larger K-factors have been determined to be capable of delivering quantities of fire retardant fluid sufficient for an ESFR sprinkler application. As the elevation of the particular hazard increases (i.e., taller warehousing), the pressure required to deliver quantities of fluid sufficient to produce the downward thrust necessary to oppose well developed fire updrafts from such elevations becomes so high as to be impractical when K-factors are less than about 8.0. However, for K-factors of about 14.0 or greater, and at the required delivered rate of fire retardant fluids, a sprinkler pressure sufficient to produce the required downward thrust by traditional deflector means is practical to achieve, but may not be as economical as desired.

In a preferred embodiment, the deflector of the invention compensates for the lower droplet velocities at the lower inlet pressures desirable for the larger K-factor sprinklers by diverting an optimized portion of the spray selectively directed within the spray pattern. The deflector is provided with at least one set of reentrant slots positioned so that their most radially inward portion is no further outward from the deflector axis than the outermost surface of the apex element of the sprinkler frame. With this arrangement, there is diverted a quantity of fire retardant fluid sufficient to produce the required amount of thrust in the inner, downwardly-directed portion of the spray pattern at pressures lower than those produced by either straight slots or slots that taper to become slightly wider in the radially outward direction.

In another aspect of the invention, the deflector body defines reentrant slots including first and second types of reentrant slots, with each type including two or more reentrant slots. At least two, generally opposing reentrant slots of the first type of reentrant slots extend through the deflector body, from the first, inside surface to the second, outside surface, with the slots opening at an outer peripheral edge of the deflector body and extending inwardly from the peripheral edge, along reentrant slot centerlines, generally toward the deflector axis, to a first type slot length. The reentrant slots of the first type have a first width measured transverse to the slot centerline in a region of the peripheral edge and a second width measured transverse to the slot centerline in a region spaced inwardly, toward the deflector axis, relative to the region of the peripheral edge, the second width being greater than the first width. At least two generally opposing reentrant slots of the second type of reentrant slots also extend through the deflector body, from the first, inside surface to the second, outside surface, with a slot opening at an outer peripheral edge of the deflector body, and extend inwardly from the peripheral edge, along a reentrant slot centerline, generally toward the deflector axis, to a second type slot length. The reentrant slots of the second type have a first width measured transverse to the slot centerline in a region of the peripheral edge and a second width measured transverse to the slot centerline in a region spaced inwardly, toward the deflector axis, relative to the region of the peripheral edge, the second width being greater than the first width. Each of the reentrant slots of the first type is disposed

between reentrant slots of the ,second type, with the first type slot lengths being different from the second type slot lengths.

With this arrangement, the use of alternating pairs of generally opposing reentrant slots of the second type provides an intermediate componentized spray pattern. The intermediate componentized spray pattern is particularly effective in ESFR sprinkler applications where updrafts in regions between the outer shell regions and regions along the central axis of the sprinkler orifice are created. Such updrafts are often created in higher elevation, higher challenge settings (e.g., warehouses) where the increased elevation allows a fire to grow to a large size before operating a sprinkler head positioned off center from the ignition point of the fire.

Embodiments of either of these aspects of the invention may include one or more of the following features. Preferably, the innermost portions of at least one pair of generally opposing reentrant slots of a first type extend inwardly toward the deflector axis so as to be no further outward from the deflector axis than the outermost surface of the apex element. The centerlines of the slots extend radially outward from the deflector axis. More preferably, the innermost portions of at least two pairs, and most preferably the innermost portions of at least four pairs, of generally opposing reentrant slots of a first type extend inwardly toward the deflector axis so as to be no further outward from the deflector axis than the outermost surface of the apex element. Preferably, the innermost portions of at least one pair of generally opposing reentrant slots of a second type extend inwardly toward the deflector axis to be no closer to the deflector axis than the outermost surface of the apex element. More preferably, the innermost portions of at least two pairs, and most preferably the innermost portions of at least four pairs, of generally opposing reentrant slots of a second type extend inwardly toward the deflector axis to be no closer than the outermost surface of the apex element.

Adjacent reentrant slots of the plurality of opposing reentrant slots of the first type are preferably circumferentially spaced around the deflector at an angle in the range of between about 175° and 185°, more preferably in the range of between about 85° and 95°, most preferably in the range of between about 40° and 50°, and optimally at an angle of about 45°. Adjacent reentrant slots of the plurality of opposing reentrant slots of the second type are preferably circumferentially spaced around the deflector at an angle in the range of between about 175° and 185°, more preferably in the range of between about 85° and 90°, most preferably in the range of between about 40° and 50°, and optimally at an angle of about 45° .in the range of between about 40° and 50°, and optimally at an angle of about 45°.

Pairs of opposing reentrant slots of the second type are disposed intermediate of and symmetrically between reentrant slots of the first type. The first type slot lengths are equal to or greater than the second type slot lengths. The centerlines of the reentrant slots of the first type extend radially outward from the deflector axis. Similarly, the centerlines of the reentrant slots of the second type also extend radially outward from the deflector axis. Preferably, all reentrant slots of the first type have an equivalent first type slot length, and all reentrant slots of the second type have an equivalent second type slot length.

The generally opposing reentrant slots of the first type comprise a portion having an elongated shape. Preferably, the generally opposing reentrant slots of the second type comprise a portion having a generally triangular shape and, more preferably, comprise a portion having a pear-shape. Preferably, the second width of the first type of reentrant slots is in the range of about 0.13 inch to about 0.17 inch, and more preferably, about 0.15 inch. Preferably, the first width of the first type of reentrant slots is in the range of about 0.08 inch to about 0.10 inch, and more preferably, about 0.09 inch. Preferably, the second width of the second type of reentrant slots is in the range of about 0.16 inch to about 0.20 inch, and more preferably, about 0.18 inch. Preferably, the first width of the second type of reentrant slots is in the range of about 0.08 inch to about 0.10 inch, and more preferably, about 0.09 inch.

The angular spacing between eight (i.e. four pairs) adjacent reentrant slots of the first type is in a range of between about 40° and 50°, preferably about 45°. Similarly, the angular spacing between eight (i.e., four pairs) adjacent reentrant slots of the second type is in a range of between about 40° and 50°, preferably about 45°. Pairs of generally opposing reentrant slots of the second type are disposed intermediate between generally opposing reentrant slots of the first type with the angular spacing between adjacent reentrant slots of the first and second types being in a range of between about 20° and 25°, and preferably about 22.5°.

Preferably, the deflector has an outside diameter greater than about 1.00 inch, more preferably, an outside diameter greater than about 1.50 inch, and most preferably an outside diameter of about 1.75 inch.

In preferred embodiments, the deflector body is a plate-like member with a thickness greater than about 0.06 inch, more preferably with a thickness greater than about 0.075 inch, and most preferably a thickness of about 0.09 inch. In the most preferred embodiment, with a deflector body thickness of about 0.09 inch, the reentrant slots are provided with additional (side) surfaces which act as fluid control or distribution surfaces, an advantage not appreciated when more traditional straight or slightly radially outwardly tapered slots are employed.

The plurality of reentrant slots extend through the deflector body, from the first, inside surface to the second, outside surface, each with a slot opening at an outer peripheral edge of the deflector body, extending inwardly from the peripheral edge, along a reentrant slot centerline, generally toward the deflector axis, each reentrant slot having a first width transverse to the slot centerline in a region of the peripheral edge and a second width transverse to the slot centerline in a region spaced inwardly, toward the deflector axis, relative to the region of the peripheral edge, the second width being greater than the first width.

The sprinkler further includes at least one arm extending from the sprinkler body containing an outlet and orifice connectable to a source of fire retardant fluid, and an apex element supported by the at least one arm, with an apex axis generally coaxial with the orifice axis, the deflector being mounted to the apex element further from the outlet than the apex element, and the innermost portion of at least one pair of opposing reentrant slots being no further outward from the apex (deflector) axis than the outermost surface of the apex element, relative to the flow of fluid.

These and other features and advantages of the invention will be apparent from the following more detailed description, and from the claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a fire protection sprinkler of the invention;

FIG. 2 is a side sectional view of the fire protection sprinkler taken at line 2—2 of FIG. 1;

FIG. 3 is a top plan view of a deflector element for use in the fire protection sprinkler of FIG. 1;

FIG. 4 illustrates a spray pattern for a fire protection sprinkler having a deflector with reentrant slots;

FIG. 5 is a top plan view of an alternate embodiment of a deflector element for use in the fire protection sprinkler of FIG. 1, and FIG. 5A is a similar enlarged view of the region A—A of FIG. 5; and

FIG. 6 illustrates a spray pattern provided by the fire protection sprinkler using the deflector element of FIG. 5.

FIG. 7 is a chart of ADD test data in a no-fire, water spray only condition for a typical straight-slotted deflector.

FIG. 8 is a chart of ADD test data with a simulated 2,000 kw fire located directly beneath the primary axis of the sprinkler for the same typical straight-slotted deflector.

FIG. 9 is a chart of ADD test data in a no-fire, water spray only condition using a sprinkler having a deflector in accordance with the invention.

FIG. 10 is a chart of ADD test data with a simulated 2,000 kw fire located directly beneath the primary axis of the sprinkler using a sprinkler having a deflector in accordance with the invention.

## DETAILED DESCRIPTION

Referring to FIGS. 1 and 2, a fire protection sprinkler **10** of the deflector impingement pendent-type has a body **12** with a base **14** defining an inlet **16** for connection to a source of fluid under pressure (not shown), and an outlet **18** (FIG. 2) with an axis, A. In certain embodiments, a strainer (not shown) may be located at inlet **16** to prevent debris larger than a preselected combination of dimensions from entering and clogging fluid flow through outlet **18**. A pair of U-shaped frame arms **22**, **24** extend from opposite sides of the base **14** to join at an apex element **26** at a position downstream of, and generally coaxial with, the outlet **18**. Apex element **26** is generally conically-shaped, with the relatively wider diameter end adjacent to a water distribution deflector **30** affixed to, and disposed coaxial with, the apex element **26**.

The outlet **18** of the fire protection sprinkler **10** is normally closed by a spring plate assembly **32**. The assembly is held in place by a thermally responsive element **34** consisting of two thin sheet metal members secured together by a low temperature fusible solder alloy which separates and automatically releases the spring plate assembly when the thermally responsive element is heated to an elevated temperature within a specified operating temperature range for a pre-selected nominal temperature rating, e.g., 74° C. (165° F.). The retention force applied by the thermally responsive element is transmitted to the spring plate assembly **32** by the load applied through a strut **35***a* via lever **35***b*. In one particular embodiment, the thermally responsive element **34** is available, e.g., from Grinnell Corporation, of Exeter, N.H., in temperature ratings of 74° C. (165° F.) and 101° C. (214° F.).

Upon release of spring plate **32**, a vertically directed, relatively coherent, single stream of fluid passes through inlet **16**, rushing downward from the outlet **18** towards the deflector **30**.

Heretofore, it has been known that the parameters establishing spray patterns for a pendent-type sprinkler operating by impacting a single, relatively coherent water jet against a substantially horizontal deflector, include:

form and/or shape of the deflector support structure;

form and/or shape of the deflector;

outside dimensions of the deflector;

shape and arrangement of openings and tines located around the periphery of the deflector; and

shape, size, and arrangement of holes located within the central area of the deflector, when such holes are utilized in conjunction with slots and tines located around the periphery of the deflector.

Referring to FIG. 3, a deflector **21** of the invention for use in pendent-type fire protection sprinkler **10** has an outside diameter, $D_1$, e.g., a uniform value of about 1.75 inches. The deflector **30** has a thickness of about 0.09 inch, and it is fabricated from a phosphor bronze alloy UNS52100, per ASTM B103, with a Rockwell B Scale hardness of about 92. The diameter of deflector **21** is optimized to provide, from a predetermined height, a particular spray pattern over a desired area to be protected from fire. The outside diameter is limited by the volume of fire retardant fluid, and by the size of the orifice. Moreover, where cost is a consideration, increasing the size of the deflector diameter requires the thickness of deflector **21** to be increased in order to ensure that it has sufficient rigidity to withstand the force of the discharged stream of fluid.

The deflector **21** has an inside surface **38** (FIG. **1**) downstream of, and facing towards, i.e. opposing, the deflector outlet **18**, and an outside surface **46** (FIG. **1**) on the opposite side of the deflector, i.e. facing away from the deflector outlet. The inside surface of the deflector **21** includes a substantially flat, central base area **48** (FIGS. **3** and **5A**) having a central hole **25** for mounting to the apex element **26**.

A grouping of equally spaced reentrant slots **29**, e.g. at least about four, and preferably about eight, as shown in FIG. 3, are symmetrically located about the periphery of the deflector through the body of the deflector **21**, i.e. from the inside surface to the opposite outside surface of the deflector. The radially innermost portions of the reentrant slots are substantially in line axially with the outer peripheral surface **27** (FIG. 2) of the apex element **26** of the sprinkler frame, or extend beneath, i.e. underlie, in the direction of fire retardant fluid flow, the outermost surface apex element **26**, as shown in FIG. 2.

With this arrangement, it has been found that a relatively greater quantity of fire retardant fluid can be diverted to produce a relatively greater amount of thrust in the inner, downwardly-directed portion (i.e., the central core) of the spray pattern at lower pressures, as compared to the amount of central core thrust generated by prior art deflectors, e.g. those having straight slots or slots which are slighted tapered in a direction radially outward from the deflector axis.

Referring to FIG. **4**, a spray pattern for a commercial ESFR fire protection sprinkler with the deflector **21** having reentrant slots **29** is illustrated. The reentrant slots **29** result in a spray pattern **2** in which the spray direction is altered towards a center main axis **3** of a sprinkler **4**. In particular, the reentrant slots **29** of the deflector result in formation of a central core **6** of spray pattern **2**, with tines of the deflector resulting in formation of an outer shell **8** of spray pattern **2**. In particular, the central core portion **6** of the spray pattern **2** has fluid droplets with greater momentum (i.e. mass times velocity), at relatively lower inlet pressures, than provided by prior art sprinklers of similar purpose.

As will be described in greater detail below, in other ESFR sprinkler applications, it may be desired to alter the spray pattern to provide additional concentrations of fluid spray, e.g., other than the central core and outer umbrella-shaped portions.

For example, referring to FIG. **5**, the deflector **30** of the deflector impingement-type, automatic fire protection sprin-

kler **10** of the invention has an outside diameter, $D_2$, e.g., a uniform value of about 1.75 inches. The deflector **30**, having a thickness, T (FIG. **1**), e.g. about 0.09 inch, is fabricated from a phosphor bronze alloy UNS52100, per ASTM B103, with a Rockwell Scale B hardness of about 92.

Referring again to FIG. **5**, as well as to FIG. **2**, deflector **30** has an inside surface **38** downstream of, and facing towards, i.e. opposing, the nozzle outlet **18**, and an outside surface **46** on the opposite side of the deflector, i.e. facing away from the nozzle outlet. The inside surface **38** of the deflector **30** includes a substantially flat, central base area **48** having a central hole **49** for mounting to the apex element **26**.

Referring particularly to FIGS. **5** and **5A**, a first grouping of a first type of equally spaced reentrant slots **54**, e.g., preferably at least one pair of generally opposing reentrant slots, more preferably at least two pairs of generally opposing slots, and most preferably about four pairs of generally opposing slots, are symmetrically located around the periphery of deflector **30** and extend from the inside surface **38** to the opposite outside surface **46**, and thus through the body of the deflector **30**. Each reentrant slot **54** extends a radial length $L_1$, e.g., in the range of about 0.52 inch to about 0.62 inch, and preferably about 0.57 inch, from an outer peripheral edge **58** of the deflector inward towards base area **48**. The reentrant slots **54** are elongated in shape and angularly spaced from each other in a range between about 40° to 50° and preferably, as shown here, the angular spacing is about 45°. Further, the elongated reentrant slots **54** have a first width, $D_{n1}$, measured transversely to the slot centerlines in a region of the peripheral edge **58**, in the range of about 0.08 inch to 0.10 inch, and preferably about 0.09 inch, and a second width, $D_{w1}$, measured transversely to the slot centerlines in a region spaced inwardly from the peripheral edge, in the range of about 0.13 inch to 0.17 inch, and preferably about 0.15 inch.

A second grouping of a second type of equally spaced reentrant slots **60** (e.g., preferably at least one pair of generally opposing slots, more preferably at two pairs of generally opposing slots, and most preferably at least four pairs of generally opposing slots, as shown in FIG. **5**) are symmetrically positioned between adjacent reentrant slots **54**. Referring also to FIG. **5A**, like reentrant slots **54**, reentrant slots **60** extend from inside surface **38** to opposite outside surface **46**, through the body of deflector **30**. Moreover, reentrant slots **60** extend from outer peripheral edge **58** of the deflector towards base area **48** by a radial length $L_2$, e.g., in the range of about 0.32 inch to about 0.42 inch, and preferably about 0.37 inch. Reentrant slots **60** are preferably pear-shaped and extend into an intermediate region **52**, with a relatively wider end **64** of each reentrant slot **60** having a radius, $r_w$, e.g., in the range of about 0.04 inch to about 0.08 inch, and preferably about 0.06 inch. The innermost, narrower end **66** of each slot **60**, located relatively closer to the deflector axis, A, than the wider portion **64**, has a radius, $r_n$, e.g., in the range of about 0.04 inch to about 0.06 inch, and preferably about 0.05 inch. Reentrant slots **60** are angularly spaced from each other in the range of between about 40° to 50° and preferably, as shown here, the angular spacing is about 45°. Further, the generally triangular-shaped or, more specifically, pear-shaped reentrant slots **60** have a first width, $D_{n2}$, measured transversely to the slot centerlines in a region of the peripheral edge **58**, in the range of about 0.08 inch to 0.10 inch, and preferably about 0.09 inch, and a second width, $D_{w2}$, measured transversely to the slot centerlines in a region spaced inwardly from the peripheral edge, in the range of 0.16 inch to 0.20 inch, and preferably about 0.18 inch.

Tines **68** are defined by that portion of the deflector body extending from central base area **48** and including those regions between reentrant slots **54** and reentrant slots **60**. The shape of reentrant slots **60** is somewhat dependent on the shape of reentrant slots **54**. In As particular, the pear-shape of reentrant slots **60** ensures that the width of tines **68** between reentrant slots **54** and **60** is sufficient to provide the desired structural rigidity to the deflector body, as well as to facilitate manufacture of the body, e.g., when stamped or machined.

Referring to FIG. **6**, in operation, a stream of fire retardant fluid, e.g. water, from the outlet **18** impacting upon the opposed, inside surface **38** of the deflector **30** is diverted generally radially downward and outward by the deflector, being broken into a spray pattern consisting of a superimposed combination of an outer, umbrella-shaped pattern component, an intermediate, componentized spray pattern component, and an inner, generally conical-shaped pattern component, the configuration of the spray pattern being primarily a function of deflector design.

Referring to FIG. **6**, and in contrast to FIG. **4**, automatic fire protection sprinkler **10** having deflector **30**, in operation, provides a spray pattern **70** well-suited for ESFR sprinkler applications. In particular, reentrant slots **54** cause the spray to form a central core **72**, tines **68** cause the spray to form an outer shell **74**, and reentrant slots **60** cause the spray to form secondary thrust regions **76** in an intermediate zone, between central core **72** and outer shell **74**, of the spray pattern **70**.

In addition, referring again to FIG. **5**, in a preferred embodiment, deflector **30** is positioned with a pair of reentrant slots **60** disposed in plane, F, of the sprinkler frame arms **22**, **24**.

A commercial embodiment of the automatic fire protection sprinkler **10** of the invention is represented by a 25.2 K-factor Model ESFR-25 pendent sprinkler assembly, as manufactured by Grinnell Corporation, 3 Tyco Park, Exeter, N.H. 03833.

Using a Model ESFR-25 sprinkler assembly, data was collected for comparison of fluid densities released over an area representing the top of stacked commodities, e.g., boxes, in a warehouse setting.

Referring to FIGS. **7–10**, the test area is shown as a pictorial array defining 0.5 meter square regions **90** representing the top surfaces of the stacked commodities, surrounded by flue regions **92**, i.e., spaces between the stacked commodities, e.g., about six inches wide. A discharging sprinkler **94** is centrally located at point **96**. The vertical distance between the sprinkler deflector and the top of the fluid collector area is 8 feet, 6 inches.

In each region there is shown a fluid density value representing the actual measured amount of fluid volume, in gallons per minute per square foot, falling within that region. The fluid density values are employed to determine weighted average values of ADD (Actual Delivered Density) over different regions of the array. Of particular interest is the region identified as "central core ADD" which represents a weighted average of the central sixteen square regions **90** and the four flue regions surrounding point **96**.

Referring to FIG. **7**, fluid density data collected using a conventional (prior art) deflector affixed to a 25.2 K-factor sprinkler with straight slots in a no-fire, water spray only condition is shown. FIG. **8** shows the fluid density data collected using the same straight-slotted deflector design in a 2,000 kw fire located directly below the primary vertical axis of the discharging 25.2 K-factor sprinkler **94**. The data shows that a substantial reduction in the collected densities

of fire protection fluid occurs when the sprinkler is tested with a 2,000 kw fire.

Referring to FIGS. **9** and **10**, fluid density data collected using a 25.2 K-factor fire protection sprinkler with a deflector **30** in accordance with the invention is shown. In particular, FIG. **9** represents collected data in the no-fire, water spray only condition and FIG. **10** represents collected data in the 2,000 kw fire condition. The aforementioned tests were conducted under identical pressure and flow conditions. Of particular interest is the substantial increase in center core ADD provided by the sprinkler having the deflector **30** of the invention, as compared to the conventional straight-slotted deflector. Moreover, this increase in center core ADD performance is achieved with substantially no sacrifice in performance at peripheral regions.

Another type of water distribution test, the so-called "10 Pan Distribution Test," such as that described in the Apr. 8, 1997, edition of UL 199, Standard for Automatic Sprinklers for Fire-Protection Service, provides another means for describing the benefit of use of reentrant slots and, in particular, the reentrant slots **60** of the deflector of this invention. Referring to FIG. 30.1 of the April 8, 1997 edition of UL 199, with a 25.2 K-factor conventional (prior art) sprinkler having straight slots and in a nofire, water spray only condition, an average water density of about 0.82 gallons per minute per square foot was measured in the 1 foot long by 1 foot wide pan centered at a 3 foot radius from the primary vertical axis of the sprinkler when it was flowing 100 gallons per minute. By comparison, with a 25.2 K-factor fire protection sprinkler having a deflector **30** in accordance with the invention, an average water density of about 1.3 gallons per minute per square foot was measured in the 1 foot long by 1 foot wide pan centered at a 3 foot radius from the primary vertical axis of the sprinkler when it was flowing 100 gallons per minute.

Other embodiments are within the following claims.

For example, the outlet **18** may have a non-circular cross-section. The sprinkler **10** may have a K-factor in the range of about 8.0 to 50.0, preferably in the range from about 14.0 to 30.0, more preferably in the range of about 22.0 to about 28.0, and most preferably the K-factor is about 25.0.

Deflectors of the invention having one group of reentrant slots, e.g. slots **27** of deflector **21** (FIG. **3**), may have slots of different lengths. In deflectors of the invention having two groups of reentrant slots, e.g. slots **54**, **60** of deflector **30** (FIG. **5**), slots within each group of slots may also have different lengths, and/or a third set of reentrant slots or holes may be employed to provide a different spray pattern. In deflectors of the invention having three groups of reentrant slots, the slots may be arranged in a pattern such as abcbabcba. The numbers of reentrant slots in each group also may vary. Moreover, the slots need not extend radially to the periphery of the deflector but may be provided in non-radial arrangements.

The peripheral edge **58** of the outer area **50** of the deflector **30** may define ridges in the radial outward direction from the deflector axis. Although deflector **30** is described above as a plate-like member, the deflector need not be flat but may, e.g., be wavy or frusto-conical in shape. The deflector **30** may also have variations in the shape and dimensions of the reentrant slots **60** through the intermediate region **52** of the deflector inner surface **38**, e.g., referring also to FIG. **5A**, in length, $L_2$, radius, $r_n$, and/or radius, $r_w$, and/or radial spacing, X, from the deflector axis, A. Frame arms **22**, **24** can have a wide variety of shapes, mounting or support arrangements, e.g., the deflector **30** may be positioned inside, rather than outside, frame arms **22**, **24**, and the frame arms may be affixed to the deflector **30**, rather than to the apex element **26**.

The apex element **26** need not be generally conically-shaped, as shown in FIG. **2**, but may be curved in the direction of the orifice axis, e.g., to achieve specific water distribution objectives. Opposing vertical sides of the reentrant slots may not be identical.

All of the above are applied without departing from the spirit and scope of this invention.

What is claimed is:

1. A pendent-type fire protection sprinkler comprising:
   - a sprinkler body defining an orifice and an outlet for delivering a flow of fluid from a source,
     - said orifice defining an orifice axis, and
     - said outlet being disposed generally coaxial with said orifice axis,
   - at least one arm extending from said sprinkler body,
   - an apex element supported by said at least one arm, with said apex axis being generally coaxial with said orifice axis, and
   - a deflector mounted to said apex element, said deflector having a deflector body defining a first, inside surface opposed to the flow of fluid and an opposite, second surface, and having a deflector axis generally coaxial with said orifice axis,
   - said deflector body defining at least one pair of generally opposing reentrant slots extending through said deflector body, from said first, inside surface to said second, outside surface, with slot openings at an outer peripheral edge of said deflector body, said reentrant slots extending inwardly from said peripheral edge, along reentrant slot centerlines, generally toward said deflector axis,
   - said reentrant slots having a first width transverse to said slot centerlines in a region of said peripheral edge and a second width transverse to said slot centerlines in a region spaced inwardly, toward said deflector axis, relative to the region of said peripheral edge, said second width being greater than said first width,
   - the innermost portions of said reentrant slots extending inwardly toward said deflector axis to be no further outward from said deflector axis than the outermost surface of said apex element.

2. The pendent-type fire protection sprinkler of claim **1**, wherein said innermost portions of said reentrant slots extend inwardly toward said deflector axis to underlie said apex element, relative to the flow of fluid.

3. The pendent-type fire protection sprinkler of claim **1**, wherein said slot centerlines extend radially outward from said deflector axis.

4. The pendent-type fire protection sprinkler of claim **1**, wherein the thickness of said deflector body from said inside surface to said outside surface is equal to or greater than about 0.06 inch.

5. The pendent-type fire protection sprinkler of claim **4**, wherein the thickness of said deflector body from said inside surface to said outside surface is equal to or greater than about 0.075 inch.

6. The pendent-type fire protection sprinkler of claim **5**, wherein the thickness of said deflector body from said inside surface to said outside surface is equal to or greater than about 0.09 inch.

7. The pendent-type fire protection sprinkler of claim **1**, wherein said deflector has an outside diameter of equal to or greater than about 1.00 inch.

8. The pendent-type fire protection sprinkler of claim **7**, wherein said deflector has an outside diameter equal to or greater than about 1.50 inches.

9. The pendent-type fire protection sprinkler of claim **8**, wherein said deflector has an outside diameter equal to or greater than about 1.75 inches.

10. The pendent-type fire protection sprinkler of claim **1**, **4** or **7**, wherein adjacent said reentrant slots are spaced at an angle in a range of between about 40° and 50°.

11. The pendent-type fire protection sprinkler of claim **10**, wherein adjacent said reentrant slots are spaced at an angle of about 45°.

12. A pendent-type fire protection sprinkler comprising:

a sprinkler body defining an orifice and an outlet for delivering a flow of fluid from a source,
said orifice defining an orifice axis, and
said outlet being disposed generally coaxial with said orifice axis,

at least one arm extending from said sprinkler body,

an apex element supported by said at least one arm, with said apex axis being generally coaxial with said orifice axis, and

a deflector mounted to said apex element, said deflector having a deflector body defining a first, inside surface opposed to the flow of fluid and an opposite, second surface, and having a deflector axis generally coaxial with said orifice axis,

said deflector body defining a plurality of reentrant slots, said plurality of reentrant slots comprising at least a first type of reentrant slots and a second type of reentrant slots,

the reentrant slots of said first type extending through said deflector body, from said first, inside surface to said second, outside surface, with slot openings at an outer peripheral edge of said deflector body, said reentrant slots of said first type extending inwardly from said peripheral edge, along reentrant slot centerlines, generally toward said deflector axis, to a first type length,

said reentrant slots of said first type having a first width transverse to said slot centerlines in a region of said peripheral edge and a second width transverse to said slot centerlines in a region spaced inwardly, toward said deflector axis, relative to the region of said peripheral edge, the second said width of said first type slots being greater than the first said width of said first type slots, and

the reentrant slots of said second type also extending through said deflector body, from said first, inside surface to said second, outside surface, with slot openings at said peripheral edge of said deflector body, said reentrant slots of said second type extending inwardly from said peripheral edge, along reentrant slot centerlines, generally toward said deflector axis, to a second type length,

said reentrant slots of said second type having a first width transverse to said slot centerlines in a region of said peripheral edge and a second width transverse to said slot centerlines in a region spaced inwardly, toward said deflector axis, relative to the region of said peripheral edge, the second said width of said second type slots being greater than the first said width of said second type slots, and

the innermost portions of said reentrant slots of said first type extending inwardly toward said deflector axis to be no further outward from said deflector axis than he outermost surface of said apex element.

13. The pendent-type fire protection sprinkler of claim **12**, wherein said first type length is equal to or greater than said second type length.

14. The pendent-type fire protection sprinkler of claim **13**, wherein said reentrant slot centerlines of said reentrant slots of said first type extend substantially radially outward from said deflector axis.

15. The pendent-type fire protection sprinkler of claim **14**, wherein said reentrant slot centerlines of said reentrant slots of said second type extend substantially radially outward from said deflector axis.

16. The pendent-type fire protection sprinkler of claim **12**, wherein said reentrant slots of said first type comprise at least two pair of generally opposing reentrant slots.

17. The pendent-type fire protection sprinkler of claim **12** or **16**, wherein said reentrant slots of said second type comprise at least two pair of generally opposing reentrant slots.

18. The pendent-type fire protection sprinkler of claim **12**, wherein said first type length of each of said plurality of said reentrant slots of said first type is substantially the same.

19. The pendent-type fire protection sprinkler of claim **12**, wherein said second type length of each of said plurality of said reentrant slots of said second type is substantially the same.

20. The pendent-type fire protection sprinkler of claim **1** or **12**, wherein said reentrant slots of said first type define a reentrant portion having an elongated shape.

21. The pendent-type fire protection sprinkler of claim **20**, wherein said second width of said first type reentrant slots is in the range of about 0.13 inch to about 0.17 inch, and said first width of said first type reentrant slots is in the range of about 0.08 inch to about 0.10 inch.

22. The pendent-type fire protection sprinkler of claim **12**, wherein said reentrant slots of said second type define a reentrant portion having a pear-shape.

23. The pendent-type fire protection sprinkler of claim **22**, wherein said second width of said second type reentrant slots is in the range of about 0.16 inch to about 0.20 inch, and said first width of said second type reentrant slots is in the range of about 0.08 inch to about 0.10 inch.

24. The pendent-type fire protection sprinkler of claim **12** or **14**, wherein the angular spacing between adjacent reentrant slots of said first type is in a range between about 40° and 50°.

25. The pendent-type fire protection sprinkler of claim **24**, wherein the angular spacing between adjacent reentrant slots of said first type is about 45°.

26. The pendent-type fire protection sprinkler of claim **12**, **15** or **23**, wherein the angular spacing between adjacent reentrant slots of said second type is in a range between about 40° and 50°.

27. The pendent-type fire protection sprinkler of claim **26**, wherein the angular spacing between adjacent reentrant slots of said second type is about 45°.

28. The pendent-type fire protection sprinkler of claim **12**, wherein said reentrant slots of said second type are located intermediate to said reentrant slots of said first type and the angular spacing between adjacent reentrant slots is in a range of between about 20° and 25°.

29. The pendent-type fire protection sprinkler of claim **28**, wherein the angular spacing between adjacent reentrant slots is about 22.5°.

30. The pendent-type fire protection sprinkler of claim **12**, wherein the thickness of said deflector body from said inside surface to said outside surface is equal to or greater than about 0.060 inch.

31. The pendent-type fire protection sprinkler of claim **30**, wherein the thickness of said deflector body from said inside surface to said outside surface is equal to or greater than about 0.075 inch.

**32**. The pendent-type fire protection sprinkler of claim **31**, wherein the thickness of said deflector body from said inside surface to said outside surface is equal to or greater than about 0.09 inch.

**33**. The pendent-type fire protection sprinkler of claim **12**, wherein the deflector has an outside diameter equal to or greater than about 1.00 inch.

**34**. The pendent-type fire protection sprinkler of claim **33**, wherein said deflector has an outside diameter equal to or greater than about 1.50 inches.

**35**. The pendent-type fire protection sprinkler of claim **34**, wherein said deflector has an outside diameter equal to or greater than about 1.75 inches.

**36**. A pendent-type fire protection sprinkler comprising:

a sprinkler body defining an orifice and an outlet for delivering a flow of fluid from a source,
said orifice defining an orifice axis, and
said outlet being disposed generally coaxial with said orifice axis,

at least one arm extending from said sprinkler body,

an apex element supported by said at least one arm, with said apex axis being generally coaxial with said orifice axis, and

a deflector mounted to said apex element, said deflector having a deflector body defining a first, inside surface opposed to the flow of fluid and an opposite, second surface, and having a deflector axis generally coaxial with said orifice axis,

said deflector body defining at least one pair of generally opposing reentrant slots extending through said deflector body, from said first, inside surface to said second, outside surface, with slot openings at an outer peripheral edge of said deflector body, said reentrant slots extending inwardly from said peripheral edge, along reentrant slot centerlines, generally toward said deflector axis,

said reentrant slots having a first width transverse to said slot centerlines in a region of said peripheral edge and a second width transverse to said slot centerlines in a region spaced inwardly, toward said deflector axis, relative to the region of said peripheral edge, the second width being greater than the first width, wherein the thickness of said deflector body from said inside surface to said outside surface is equal to or greater than about 0.06 inch.

**37**. The pendent-type fire protection sprinkler of claim **36**, wherein the thickness of said deflector body from said inside surface to said outside surface is equal to or greater than about 0.075 inch.

**38**. The pendent-type fire protection sprinkler of claim **37**, wherein the thickness of said deflector body from said inside surface to said outside surface is equal to or greater than about 0.09 inch.

**39**. The pendent-type fire protection sprinkler of claim **36**, wherein said innermost portions of said reentrant slots extend inwardly toward said deflector axis to be no further outward from said deflector axis than the outermost surface of said apex element, relative to the flow of fluid.

**40**. The pendent-type fire protection sprinkler of claim **36**, wherein said slot centerlines extend radially outward from said deflector axis.

**41**. The pendent-type fire protection sprinkler of claim **36**, wherein said deflector has an outside diameter equal to or greater than about 1.00 inch.

**42**. The pendent-type fire protection sprinkler of claim **41**, wherein said deflector has an outside diameter equal to or greater than about 1.50 inch.

**43**. The pendent-type fire protection sprinkler of claim **42**, wherein said deflector has an outside diameter equal to or greater than about 1.75 inches.

**44**. The pendent-type fire protection sprinkler of claim **36** or **41**, wherein adjacent said reentrant slots are spaced at an angle in a range of between about 40° and 50°.

**45**. The pendent-type fire protection sprinkler of claim **44**, wherein adjacent said reentrant slots are spaced at an angle of about 45°.

**46**. The pendent-type fire protection sprinkler of claim **1**, **12** or **36**, wherein said orifice has a K-factor in the range of from about 8.0 to 50.0.

**47**. The pendent-type fire protection sprinkler of claim **46**, wherein said orifice has a K-factor in the range of from about 14.0 to 30.0.

**48**. The pendent-type fire protection sprinkler of claim **47**, wherein said orifice has a K-factor of about 25.0.

**49**. The pendent-type fire protection sprinkler of claim **5**, **31** or **37**, wherein said orifice has a K-factor in the range of from about 8.0 to 50.0.

**50**. The pendent-type fire protection sprinkler of claim **49**, wherein said orifice has a K-factor in the range of from about 14.0 to 30.0.

**51**. The pendent-type fire protection sprinkler of claim **50**, wherein said orifice has a K-factor of about 25.0.

**52**. The pendent-type fire protection sprinkler of claim **6**, **32** or **38**, wherein said orifice has a K-factor in the range of from about 8.0 to 50.0.

**53**. The pendent-type fire protection sprinkler of claim **52**, wherein said orifice has a K-factor in the range of from about 14.0 to 30.0.

**54**. The pendent-type fire protection sprinkler of claim **53**, wherein said orifice has a K-factor of about 25.0.

**55**. A pendent-type fire protection sprinkler comprising:

a sprinkler body defining an orifice and an outlet for delivering a flow of fluid from a source,
said orifice defining an orifice axis, and
said outlet being disposed generally coaxial with said orifice axis,

at least one arm extending from said sprinkler body, an apex element supported by said at least one arm, with said apex axis being generally coaxial with said orifice axis, and

a deflector mounted to said apex element, said deflector having a deflector body defining a first, inside surface opposed to the flow of fluid and an opposite, second surface, and having a deflector axis generally coaxial with said orifice axis,

wherein, when said sprinkler is tested in accordance with the "Ten Pan Distribution Test" described in the Apr. 8, 1997, edition of UL 199, Standard for Automatic Sprinklers for Fire Protection Service, at a flowing water rate of 100 gallons per minute, an average water density of equal to or greater than about 1.00 gallons per minute per square foot is delivered for collection into a one foot long by one foot wide pan centered at a three foot radius from said orifice axis.

**56**. The pendent-type fire protection sprinkler of claim **55**, wherein an average water density of equal to or greater than about 1.15 gallons per minute per square foot is delivered for collection.

**57**. The pendent-type fire protection sprinkler of claim **56**, wherein an average water density of equal to or greater than about 1.30 gallons per minute per square foot is delivered for collection.

**58**. The pendent-type fire protection sprinkler of claim **55**, wherein said orifice has a K-factor in the range of from about 8.0 to 50.0.

59. The pendent-type fire protection sprinkler of claim 58, wherein said orifice has a K-factor in the range of from about 14.0 to 30.0.

60. The pendent-type fire protection sprinkler of claim 59, wherein said orifice has a K-factor of about 25.0.

61. The pendent-type fire protection sprinkler of claim 55, wherein said deflector has an outside diameter equal to or greater than about 1.00 inch.

62. The pendent-type fire protection sprinkler of claim 61, wherein said deflector has an outside diameter equal to or greater than about 1.50 inch.

63. The pendent-type fire protection sprinkler of claim 62, wherein said deflector has an outside diameter equal to or greater than about 1.75 inches.

64. The pendent-type fire protection sprinkler of claim 55, wherein the thickness of said deflector body from said inside surface to said outside surface is equal to or greater than about 0.060 inch.

65. The pendent-type fire protection sprinkler of claim 64, wherein the thickness of said deflector body from said inside surface to said outside surface is equal to or greater than about 0.075 inch.

66. The pendent-type fire protection sprinkler of claim 65, wherein the thickness of said deflector body from said inside surface to said outside surface is equal to or greater than about 0.09 inch.

67. A pendent-type fire protection sprinkler comprising:

a sprinkler body defining an orifice and an outlet for delivering a flow of fluid from a source,

said orifice defining an orifice axis, and

said outlet being disposed generally coaxial with said orifice axis,

at least one arm extending from said sprinkler body,

an apex element supported by said at least one arm, with said apex axis being generally coaxial with said orifice axis, and

a deflector mounted to said apex element, said deflector having a deflector body defining a first, inside surface opposed to the flow of fluid and an opposite,. second surface, and having a deflector axis generally coaxial with said orifice axis,

said fire protection sprinkler adapted, upon impingement of a flow of fire-retardant fluid upon said deflector, to distribute the fire-retardant fluid over an area to be protected from fire, said area being generally confined within a spray pattern of said fire protection sprinkler, said spray pattern comprising at least three portions defined radially from a central axis of said fire protection sprinkler, a first said portion being most radially central, a second said portion being more radially distant, and a third said portion being most radially remote, all with respect to said central axis, said fire retardant fluid being distributed by said fire protection sprinkler in a specific space quantity relationship in each of said portions such that said spray pattern is specifically adapted for fire suppression, wherein said first portion receives the relatively greatest quantity per unit area of fire retardant fluid within said spray pattern, said second portion receives a greater quantity per unit of fire retardant fluid within said spray pattern than said third portion, and said second portion is segregated into adjacent zones of different concentrations of fire retardant fluid.

68. A deflector of the type used with a fire protection sprinkler, said deflector comprising:

a generally flat, plate-like body member having a deflector axis and defining:

an inner surface opposed to flow of fluid from an outlet of a sprinkler,

an opposite, outer surface,

a mounting region disposed along the deflector axis and configured for connection to a sprinkler,

a first plurality of re-entrant slots, each re-entrant slot of said first plurality of re-entrant slots extending from said inner surface to said outer surface and having a first slot length extending radially inward from a peripheral edge of said body member and toward said deflector axis,

a second plurality of re-entrant slots, each re-entrant slot of said second plurality of re-entrant slots extending from said inner surface to said outer surface and having a second slot length extending radially inward from a peripheral edge of the deflector and toward said deflector axis, each re-entrant slot of said second plurality of re-entrant slots positioned between adjacent re-entrant slots of said first plurality of re-entrant slots, said second slot length being relatively less than said first slot length.

69. The deflector of claim 1 wherein the first plurality of re-entrant slots includes at least four re-entrant slots.

70. The deflector of claim 69 wherein the second plurality of re-entrant slots includes at least four re-entrant slots.

71. The deflector of claim 68 wherein the first plurality of re-entrant slots have an elongated shape.

72. The deflector of claim 68 wherein the second plurality of re-entrant slots are pear-shaped.

73. The deflector of claim 72 wherein each of the second plurality of re-entrant slots has a first, relatively wider end and a second, relatively narrower end, said first, relatively wider end being relatively farther from said central axis than said second, relatively narrower end.

74. The deflector of claim 73 wherein said first, relatively wider end has a radius in the range of about 0.08 inch to about 0.10 inch, and said second, relatively narrower end has a radius in the range of about 0.04 inch to about 0.05 inch.

75. The deflector of claim 68 wherein the angular spacing between adjacent ones of the first plurality of reentrant slots is in a range between about 40° and 50°.

76. The deflector of claim 75 wherein the angular spacing between adjacent ones of the first plurality of reentrant slots is about 45°.

77. The deflector of claim 76 wherein the angular spacing between adjacent ones of the second plurality of reentrant slots is in a range between about 40° and 50°.

78. the deflector of claim 77 wherein the angular spacing between adjacent ones of the second plurality of reentrant slots is about 45°.

79. The deflector of claim 68 wherein the plate-like body member has a thickness greater than about 0.060 inch.

80. The deflector of claim 68 wherein the plate-like body member has a diameter greater than 1.0 inch.

81. A fire protection sprinkler comprising:

a body defining an orifice and an outlet for flow of fluid from a source,

said orifice defining an axis, and

said outlet being disposed generally coaxial with said orifice, and

a deflector disposed generally coaxial with said axis of said orifice and positioned for impingement of the flow of fluid thereupon, said deflector defining:

an inner surface opposed to flow of fluid from said outlet,

an opposite, outer surface,

a first plurality of re-entrant slots extending from said inner surface to said outer surface, each re-entrant

slot of said first plurality of re-entrant slots having a first slot length extending radially inward from a peripheral edge of the deflector and toward the axis of the orifice,

a second plurality of re-entrant slots extending from said inner surface to said outer surface, each re-entrant slot of said second plurality of re-entrant slots having a second slot length extending radially inward from a peripheral edge of the deflector and toward the axis of the orifice, each re-entrant slot of said second plurality of re-entrant slots positioned between adjacent re-entrant slots of said first plurality of reentrant slots, said first slot length being relatively greater than said second slot length.

**82**. The fire protection sprinkler of claim **81** wherein the first plurality of re-entrant slots includes at least four re-entrant slots.

**83**. The fire protection sprinkler of claim **82** wherein the second plurality of re-entrant slots includes at least four re-entrant slots.

**84**. The fire protection sprinkler of claim **81** wherein the first plurality of re-entrant slots have an elongated shape.

**85**. The fire protection sprinkler of claim **81** wherein the second plurality of re-entrant slots are pear-shaped.

**86**. The fire protection sprinkler of claim **85** wherein each of the second plurality of re-entrant slots has a first, relatively wider end and a second, relatively narrower end, said first, relatively wider end being relatively closer to said central axis than said second, relatively narrower end.

**87**. The fire protection sprinkler of claim **19** wherein said first, relatively wider end has a radius in the range of about 0.08 inch to about 0.10 inch, and said second, relatively narrower end has a radius in the range of about 0.04 inch to about 0.05 inch.

**88**. The fire protection sprinkler of claim **81** wherein the angular spacing between the first plurality of re-entrant slots and the second plurality of re-entrant slots is in a range between about 40° and 50°.

**89**. The fire protection sprinkler of claim **88** wherein the angular spacing between the first plurality of reentrant slots and the second plurality of re-entrant slots is about 45°.

**90**. The fire protection sprinkler of claim **89** wherein the angular spacing between the first plurality of re-entrant slots and the second plurality of re-entrant slots is in a range between about 40° and 50°.

**91**. The fire protection sprinkler of claim **20** wherein the angular spacing between the first plurality of re-entrant slots and the second plurality of re-entrant slots is about 45°.

**92**. The fire protection sprinkler of claim **81** wherein the plate-like body member has a thickness greater than about 0.060 inch.

**93**. The fire protection sprinkler of claim **81** wherein the plate-like body member has a diameter greater than 1.0 inch.

**94**. A fire protection sprinkler comprising:

a body defining an orifice and an outlet for flow of fluid from a source,

said orifice defining an axis, and

said outlet being disposed generally coaxial with said orifice,

an apex member positioned along the axis and below the outlet, and

a deflector disposed generally coaxial with said axis of said orifice and positioned beneath the apex member for impingement of the flow of fluid thereupon, said deflector defining:

an inner surface opposed to water flow from said outlet,

an opposite outer surface, and

a plurality of re-entrant slots extending from said inner surface to said outer surface and having a slot length extending radially inward from a peripheral edge of the deflector and toward the axis of the orifice, a most radially inward portion of the re-entrant slots extending within the outer periphery of the apex member.

**95**. The fire protection sprinkler of claim **94** wherein the plurality of re-entrant slots includes at least four re-entrant slots.

**96**. The fire protection sprinkler of claim **94** wherein the angular spacing between adjacent ones of the plurality of re-entrant slots is in a range between about 40° and 50°

**97**. The fire protection sprinkler of claim **94** wherein the plate-like body member has a thickness greater than about 0.060 inch.

**98**. The fire protection sprinkler of claim **94** wherein the plate-like body member has a diameter greater than 1.0 inch.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 6,059,044
DATED : May 9, 2000
INVENTOR(S) : Michael A. Fischer



It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 2,
Line 18, Insert left parenthesis --(-- before the last "s" in "sprinklers)".

Column 3,
Line 67, delete "gape" and insert—"P".

Column 5,
Line 1, delete comma "," before "the second type,".

Column 18,
Line 21, delete "claim 1" and insert -- claim 68 --.

Column 19,
Line 30, delete "claim 19" and insert -- claim 86 --.

Signed and Sealed this

Twenty-eighth Day of August, 2001

*Attest:*

Nicholas P. Godici

NICHOLAS P. GODICI

*Attesting Officer*

*Acting Director of the United States Patent and Trademark Office*

US005862994A

# United States Patent [19]

**Pounder et al.**

[11] **Patent Number: 5,862,994**

[45] **Date of Patent: Jan. 26, 1999**

[54] **DEFLECTOR FOR UPRIGHT-TYPE FIRE SPRINKLERS**

[75] Inventors: **Donald B. Pounder**, North Kingstown; **Michael A. Fischer**, West Kingston, both of R.I.

[73] Assignee: **Grinnell Corporation**, Cranston, R.I.

[21] Appl. No.: **671,814**

[22] Filed: **Jun. 25, 1996**

[51] **Int. Cl.**[6] .......... **B05B 1/26**

[52] **U.S. Cl.** .......... **239/498**; 239/504; 239/518; 169/37

[58] **Field of Search** .......... 239/498, 504, 239/518, 521, 523, 524; 169/37, 38, 39, 41

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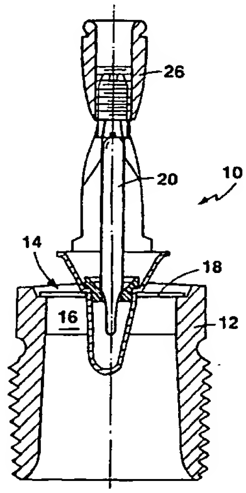
*Primary Examiner*—J. Casimer Jacyna
*Attorney, Agent, or Firm*—Fish & Richardson P.C.

[57] **ABSTRACT**

An upright-type fire protection sprinkler with a body defining an orifice and outlet for flow of fluid, and a deflector positioned coaxial with the outlet for impingement of fluid flow thereupon, has one or a combination of the following features for improved performance. The deflector may have an inner surface with a recessed central area, and a recessed redirecting area about the central area at a predetermined acute angle and axial offset thereto. The deflector has tines with inner surfaces inclined towards the outlet, at least a first set of tines disposed in planes at about 45° to a first plane of sprinkler frame arms, the surfaces of the first set of tines being inclined at an angle relatively more outward from the axis than the angle of inner surfaces of adjacent tines. The tines may include a second set of tines in a plane perpendicular to the first plane, and a third set of tines in the first plane, inner surfaces of the second set of tines having a second set width and inner surfaces of the third set of tines having a third set width about 0.15 to 0.65 times the second set width. The second set width may be substantially greater than widths of inner surfaces of all other tines.

**35 Claims, 7 Drawing Sheets**



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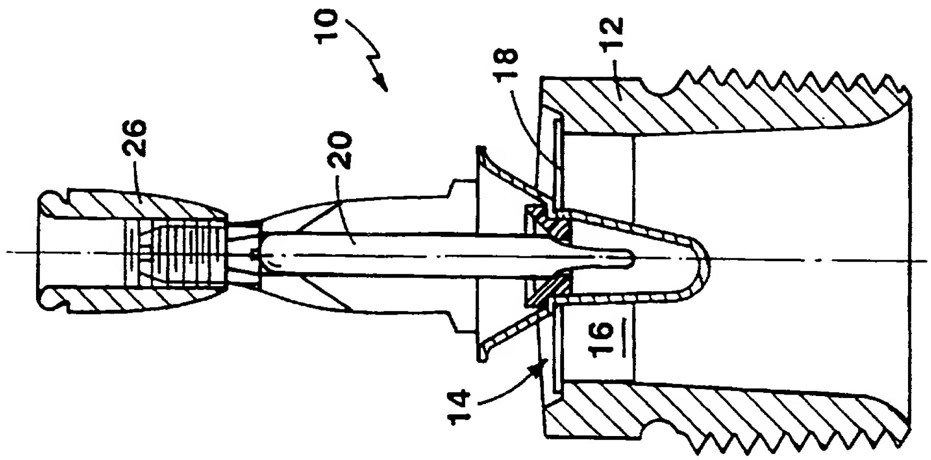



FIG. 2

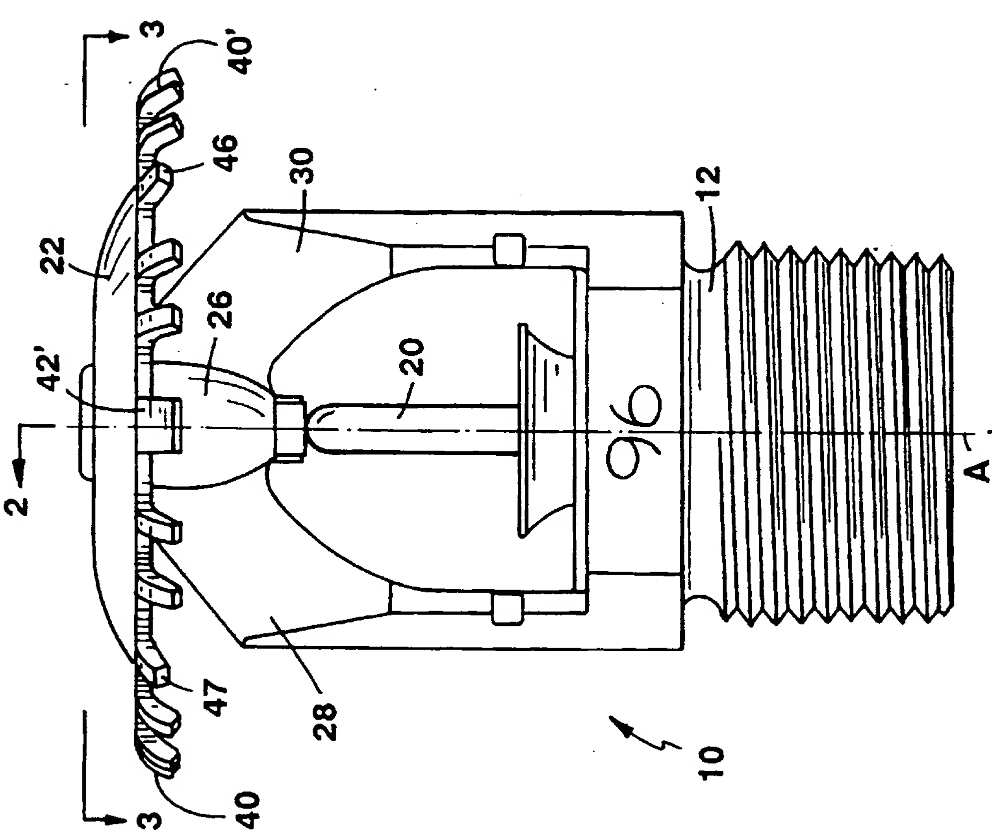



FIG. 1

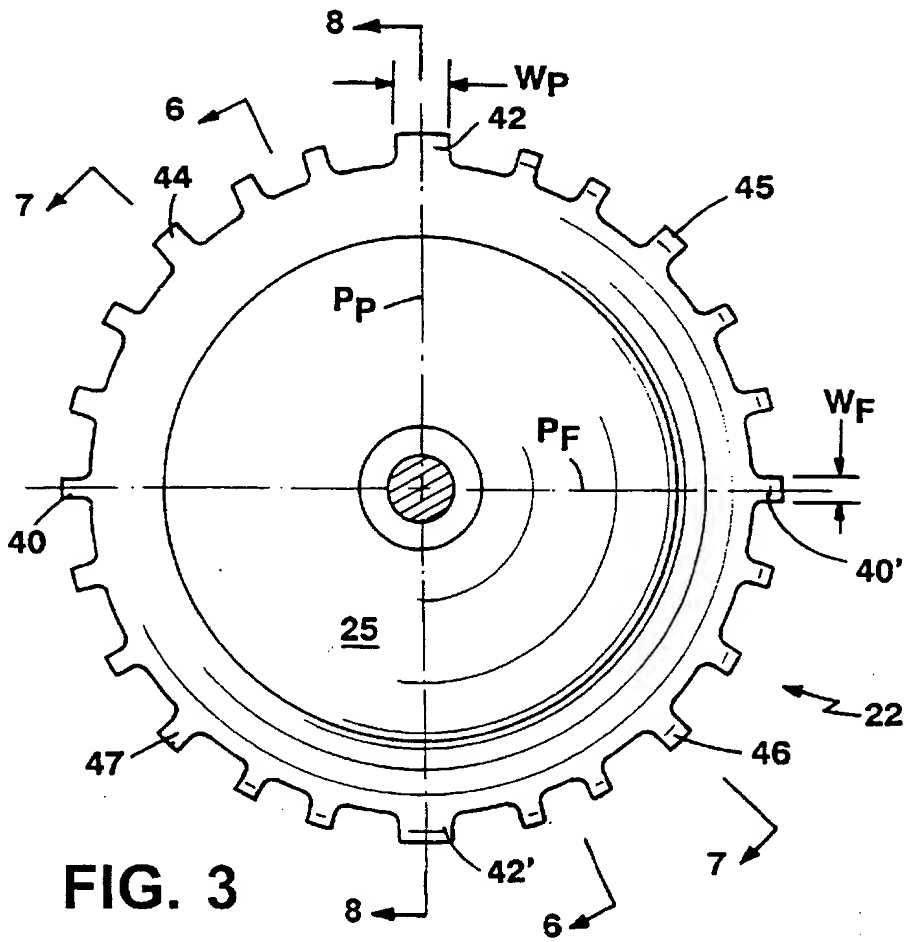



FIG. 3

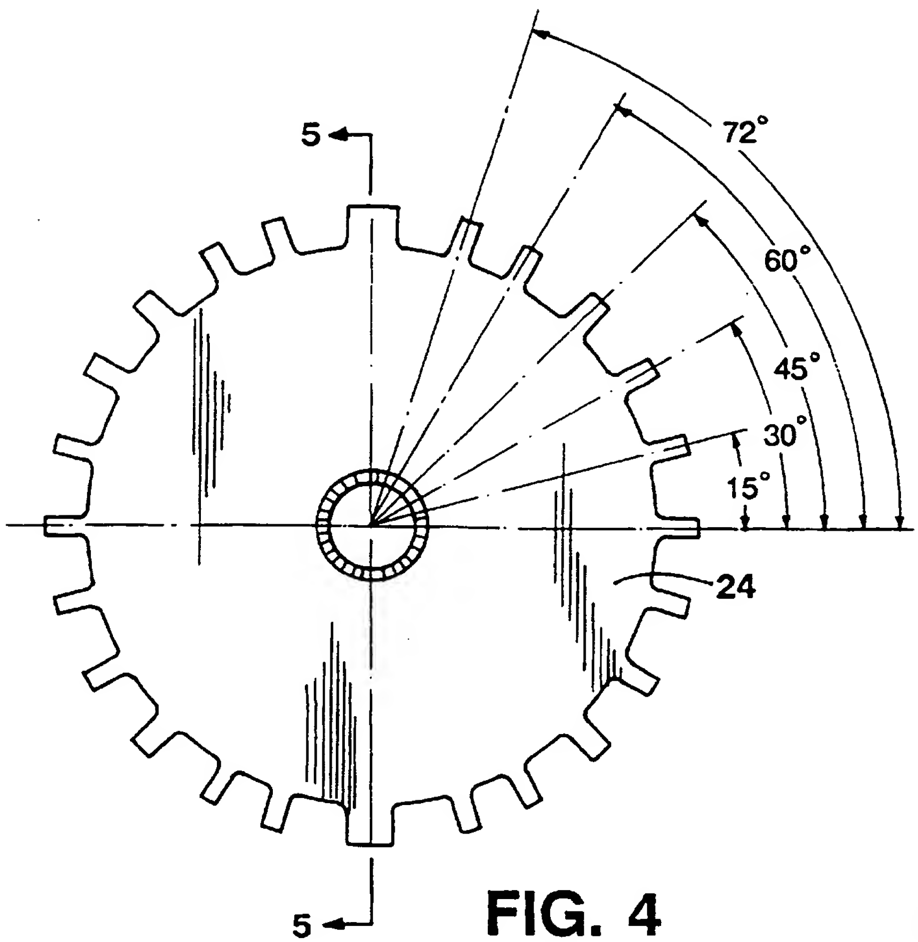



FIG. 4

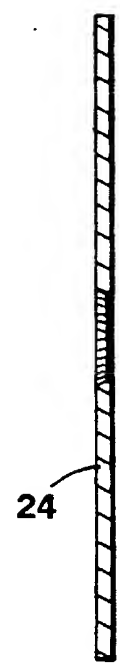



FIG. 5

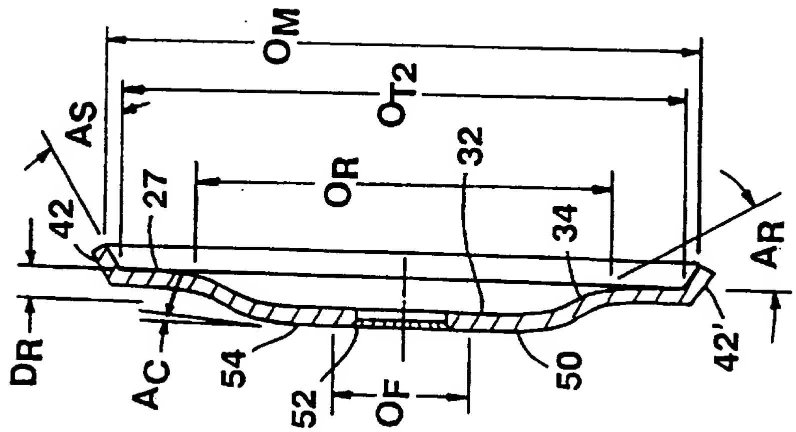



FIG. 8

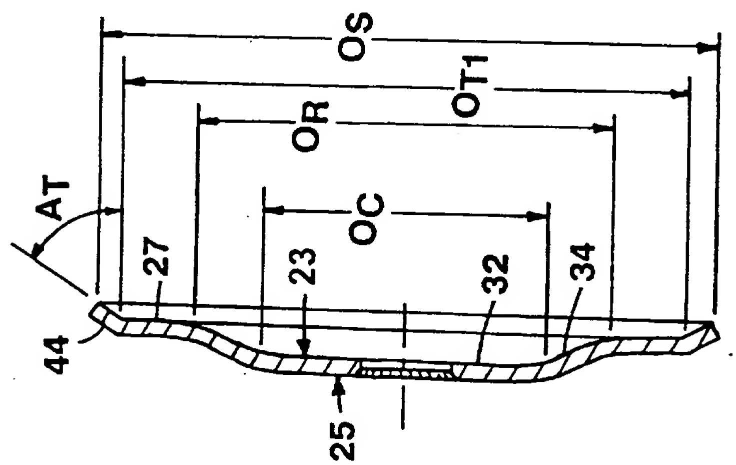



FIG. 7

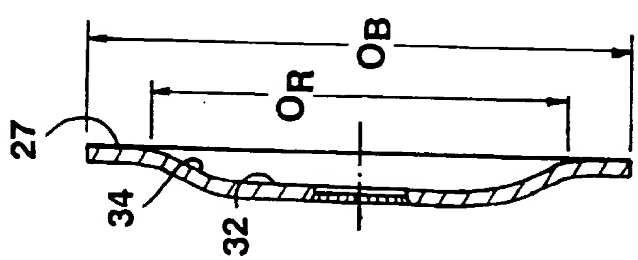



FIG. 6

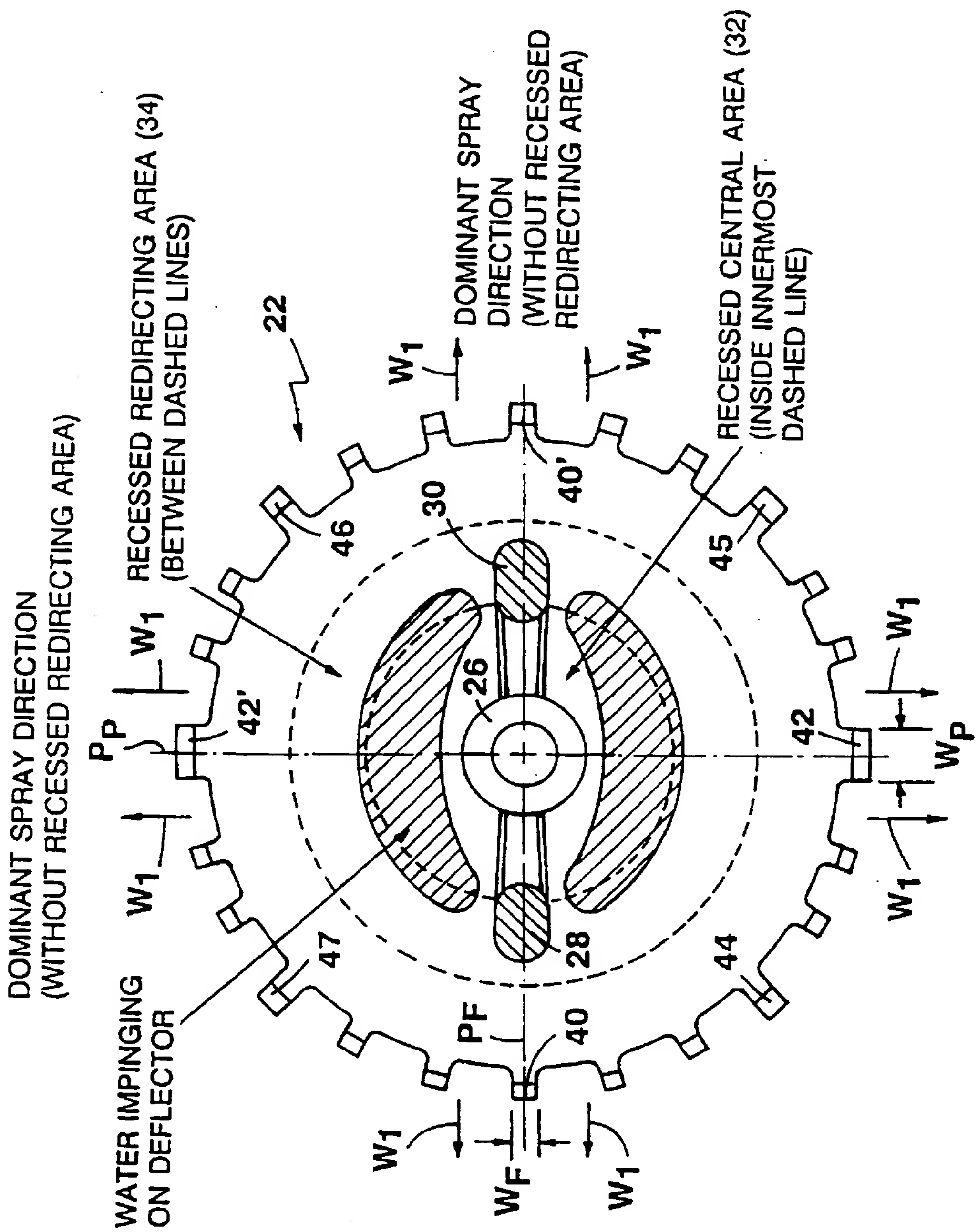

DOMINANT SPRAY DIRECTION (WITHOUT RECESSED REDIRECTING AREA)
RECESSED REDIRECTING AREA (34) (BETWEEN DASHED LINES)
22
DOMINANT SPRAY DIRECTION (WITHOUT RECESSED REDIRECTING AREA)
RECESSED CENTRAL AREA (32) (INSIDE INNERMOST DASHED LINE)
WATER IMPINGING ON DEFLECTOR
$W_1$
$W_P$
$W_F$
$P_P$
$P_F$
26
28
30
40
40'
42
42'
44
45
46
47

FIG. 9

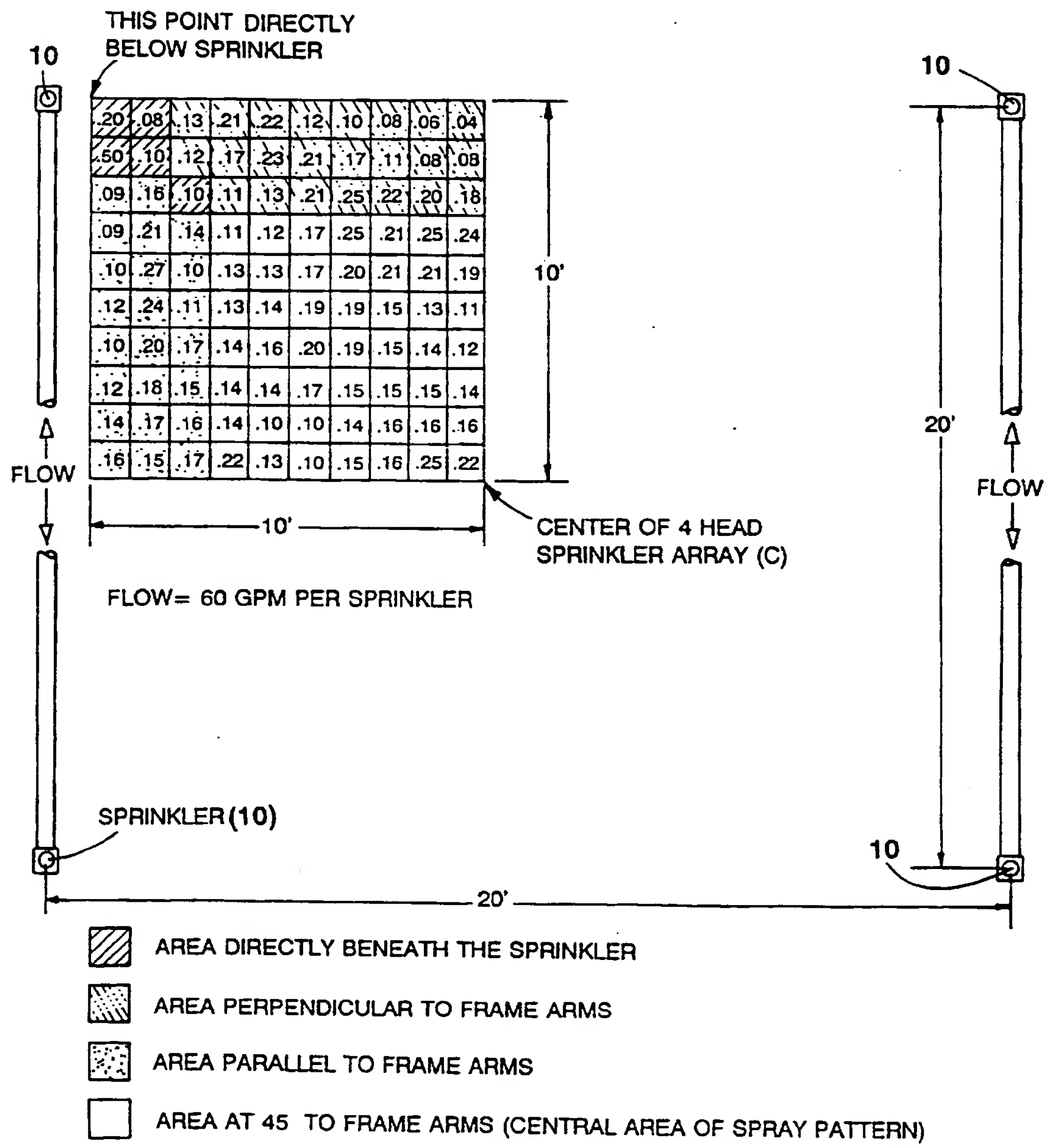
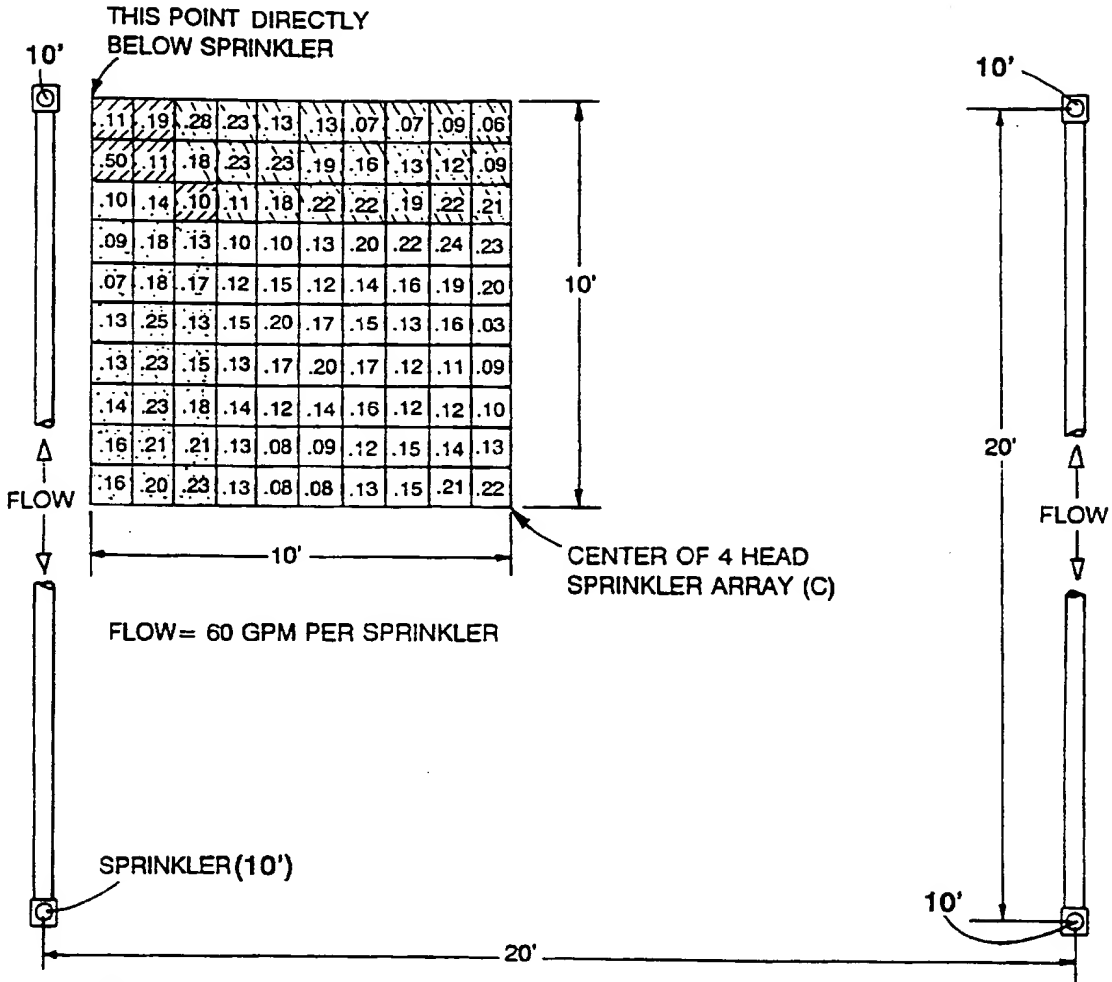

THIS POINT DIRECTLY BELOW SPRINKLER
10
10
.20 .08 .13 .21 .22 .12 .10 .08 .06 .04
.50 .10 .12 .17 .23 .21 .17 .11 .08 .08
.09 .16 .10 .11 .13 .21 .25 .22 .20 .18
.09 .21 .14 .11 .12 .17 .25 .21 .25 .24
.10 .27 .10 .13 .13 .17 .20 .21 .21 .19
.12 .24 .11 .13 .14 .19 .19 .15 .13 .11
.10 .20 .17 .14 .16 .20 .19 .15 .14 .12
.12 .18 .15 .14 .14 .17 .15 .15 .15 .14
.14 .17 .16 .14 .10 .10 .14 .16 .16 .16
.16 .15 .17 .22 .13 .10 .15 .16 .25 .22
10'
10'
20'
FLOW
FLOW
CENTER OF 4 HEAD SPRINKLER ARRAY (C)
FLOW= 60 GPM PER SPRINKLER
SPRINKLER (10)
10
20'
AREA DIRECTLY BENEATH THE SPRINKLER
AREA PERPENDICULAR TO FRAME ARMS
AREA PARALLEL TO FRAME ARMS
AREA AT 45 TO FRAME ARMS (CENTRAL AREA OF SPRAY PATTERN)

FIG. 10




AREA DIRECTLY BENEATH THE SPRINKLER

AREA PERPENDICULAR TO FRAME ARMS

AREA PARALLEL TO FRAME ARMS

AREA AT 45 TO FRAME ARMS (CENTRAL AREA OF SPRAY PATTERN)

FIG. 11

# DEFLECTOR FOR UPRIGHT-TYPE FIRE SPRINKLERS

## BACKGROUND OF THE INVENTION

The invention relates to fire protection sprinklers.

An automatic fire sprinkler has a body with an outlet that is normally closed by a plug, the plug being held in place by a heat-activated trigger mechanism, and an orifice which is normally coincident with or just upstream of the outlet.

Automatic sprinklers of the upright type also have a substantially horizontal water distribution deflector that faces the outlet. When a sufficiently elevated temperature is sensed, a thermally responsive element which normally retains the plug in a closed position releases the plug, a vertically directed stream of water (downward for pendent sprinklers and upward for upright sprinklers) discharges from the outlet orifice towards the deflector. The water impacts and is diverted generally radially downward and outward by the deflector, breaking up into a spray pattern, the shape of which is, in large part, a function of the deflector configuration, the water being projected over the intended area of coverage, i.e., the protected area.

## SUMMARY OF THE INVENTION

According to one aspect of the invention, an upright fire protection sprinkler comprises a body defining an orifice and outlet for flow of fluid from a source, and a deflector disposed generally coaxial with the outlet and positioned for impingement of the flow of fluid thereupon, the deflector defining an inner surface opposed to water flow from the outlet and an opposite outer surface, the inner surface defining: a central area about the axis, a redirecting area extending about the periphery of the central area at a predetermined acute angle and predetermined axial offset thereto, relative to the horizontal, the redirecting surface being essentially free of through openings from the inner surface of the deflector to the opposite outer surface, and a base area radially outward of the redirecting area, the central area and the redirecting area being recessed from the outlet relative to the base area.

Preferred embodiments of this aspect of the invention may include one or more of the following additional features. The predetermined acute angle is between about 10° to 45°, preferably between about 22° to 32°, and more preferably about 27°. The predetermined axial offset is between about 0.030 inch and 0.210 inch, preferably between about 0.090 inch and 0.150 inch, and more preferably about 0.120 inch. The upright fire protection sprinkler further comprises a pair of frame arms extending from the body and disposed generally in a first plane including the axis, with the deflector mounted thereupon, the deflector further comprising a plurality of tines defining inner tine surfaces inclined towards the outlet. Preferably, the inner tine surfaces of a first set of tines disposed in planes at about 45° to the first plane are inclined at a first predetermined angle which is relatively more outward than a second predetermined angle of adjacent inner tine surfaces. More preferably, the first predetermined angle is between about 10° to 45°, preferably between about 22° to 33°, and more preferably about 27°30', further from the vertical than the second predetermined angle. A second set of tines generally in a plane perpendicular to the first plane have a predetermined second set width and a third set of tines in the first plane including the frame arms has a predetermined third set width, the predetermined third set width being about 0.15 to 0.65 times, preferably about 0.30 to 0.50 times, and more preferably about 0.40 times the predetermined second set width. Preferably, the predetermined second set width is about 0.150 inch and the predetermined third set width is about 0.060 inch. The plurality of tines comprises a second set of tines disposed generally in a plane perpendicular to the first plane, the inner tine surfaces of the second set of tines having a predetermined second set width, the predetermined second width being substantially greater than widths of the inner tine surfaces of all other of the plurality of tines. Preferably, the predetermined second width is about 0.150 inch.

According to another aspect of the invention, an upright fire protection sprinkler comprises: a body defining an orifice and outlet for flow of fluid from a source, a deflector disposed generally coaxial with the outlet and positioned for impingement of the flow of fluid thereupon, and a pair of frame arms extending from the body and disposed generally in a first plane including the axis, with the deflector mounted thereupon, the deflector comprising a plurality of tines defining inner tine surfaces inclined towards the outlet, the plurality of tines comprising a first set of tines disposed in planes at about 45° to the first plane, the inner tine surfaces of the first set of tines being inclined at a first predetermined angle which is relatively more outward from the axis than a second predetermined angle of the inner tine surfaces of adjacent the tines.

Preferred embodiments of this aspect of the invention may include one or more of the following additional features. Preferably, the first predetermined angle is between about 10° to 45°, preferably between about 22° to 33°, and more preferably about 27°30', further from the vertical than the second predetermined angle. The deflector further defines an inner surface opposed to water flow from the outlet and an opposite outer surface, the inner surface defining: a central area about the axis, a redirecting area extending about the periphery of the central area at a predetermined acute angle and predetermined axial offset thereto, relative to the horizontal, the redirecting surface being essentially free of through openings from the inner surface of the deflector to the opposite outer surface, and a base area radially outward of the redirecting area, the central area and the redirecting area being recessed from the outlet relative to the base area.

According to another aspect of the invention, an upright fire protection sprinkler comprises: a body defining an orifice and outlet for flow of fluid from a source, a deflector disposed generally coaxial with the outlet and positioned for impingement of the flow of fluid thereupon, and a pair of frame arms extending from the body and disposed generally in a first plane including the axis, with the deflector mounted thereupon, the deflector comprising a plurality of tines defining inner tine surfaces inclined towards the outlet, the plurality of tines comprising a second set of tines disposed generally in a plane perpendicular to the first plane, and a third set of tines disposed in the first plane including the frame arms, the inner tine surfaces of the second set of tines having a predetermined second set width and the inner tine surfaces of the third set of tines having a predetermined third set width, the predetermined third set width being about 0.15 to 0.65 times the predetermined second set width.

Preferred embodiments of this aspect of the invention may include one or more of the following additional features. The predetermined third set width is preferably about 0.30 to 0.50 times, and more preferably about 0.40 times the predetermined second set width. Preferably, the predetermined second set width is about 0.150 inch and the predetermined third set width is about 0.060 inch. The deflector

further defines an inner surface opposed to water flow from the outlet and an opposite outer surface, the inner surface defining: a central area about the axis, a redirecting area extending about the periphery of the central area at a predetermined acute angle and predetermined axial offset thereto, relative to the horizontal, the redirecting surface being essentially free of through openings from the inner surface of the deflector to the opposite outer surface, and a base area radially outward of the redirecting area, the central area and the redirecting area being recessed from the outlet relative to the base area.

According to still another aspect of the invention, an upright fire protection sprinkler comprises: a body defining an orifice and outlet for flow of fluid from a source, a deflector disposed generally coaxial with the outlet and positioned for impingement of the flow of fluid thereupon, and a pair of frame arms extending from the body and disposed generally in a first plane including the axis, with the deflector mounted thereupon, the deflector comprising a plurality of tines defining inner tine surfaces inclined towards the outlet, the plurality of tines comprising a second set of tines disposed generally in a plane perpendicular to the first plane, the inner tine surfaces of the second set of tines having a predetermined second set width, the predetermined second width being substantially greater than widths of the inner tine surfaces of all other of the plurality of tines.

Preferred embodiments of this aspect of the invention may include one or more of the following additional features. The predetermined second width is about 0.150 inch. The deflector further defines an inner surface opposed to water flow from the outlet and an opposite outer surface, the inner surface defining: a central area about the axis, a redirecting area extending about the periphery of the central area at a predetermined acute angle and predetermined axial offset thereto, relative to the horizontal, the redirecting surface being essentially free of through openings from the inner surface of the deflector to the opposite outer surface, and a base area radially outward of the redirecting area, the central area and the redirecting area being recessed from the outlet relative to the base area.

Preferred embodiments of each of the above aspects of the invention may also include one or more of the following additional features. The upright fire protection sprinkler has a K-factor of at least 5.0, preferably at least 7.0, more preferably at least 10.5, and still more preferably at least 13.0.

Within the past three years, the range of available fire protection products for automatic fire sprinkler systems has expanded to include ceiling sprinklers designed to cover larger or "extended coverage" areas when the occupancy being protected falls into the Ordinary Hazard category, as defined by NFPA 13, *Standard for the Installation of Sprinkler Systems*. These sprinklers are referred to as extended coverage/ordinary hazard (ECOH) sprinklers. In order to be acceptable for installation under an installation standard like NFPA 13, automatic fire sprinklers must be included in a list published by an organization acceptable to the local governmental authority having jurisdiction, and meet any additional requirements specified in the installation standard.

Organizations which list ECOH sprinklers include, for example, Underwriters Laboratories Inc. (UL) and Factory Mutual Research Corporation (FM). These types of organizations evaluate the performance of fire protection products, like the ECOH sprinklers, in accordance with established standards or guidelines, to certify that the listed fire protection products will satisfactorily perform their intended function when installed in accordance with the requirements of their listing, the manufacturer's installation instructions, and the installation standards of the authority having jurisdiction.



The standards or guidelines for evaluating ECOH sprinklers include established requirements for the minimum amount of water which must be collected, per unit time, in specified areas (i.e., density) under and between the sprinklers, when they are discharging water under specified flowing (residual pressure) conditions. Water collection may be measured both with and without the presence of fire.

In addition to meeting the minimum water density requirements, it is advantageous for fire sprinklers to spray as uniform a distribution of water as possible, whether operating individually or in groups, in order to provide the same level of fire protection performance no matter where the fire starts within the protected area. This is particularly difficult to achieve for ECOH sprinklers designed for use over a range of coverage areas from 14 ft by 14 ft to 20 ft by 20 ft.

The shape of the water spray pattern directly affects the circulation of air in the vicinity of the discharging sprinkler. By shaping the deflector so that water is directed primarily radially outward in an umbrella-shaped pattern, i.e., initially generally parallel to the ceiling under which the sprinkler is located, the thrust of the water jet is directed so that air along the ceiling is entrained by the water flow and swept outward and away from the sprinkler. At the edges of the spray pattern, the air descends and circulates inward along the floor toward the center of the spray pattern where it billows up, similar to a rising cumulus cloud.

Alternatively, by shaping the deflector so that water is directed primarily downward in a more conical pattern, the thrust of the water jet is such that air is entrained by the downwardly directed water and "pulls" air in along the ceiling toward the sprinkler. This sets up a different overall circulation pattern. Depending on the intended fire protection application of the sprinkler, either spray and circulation pattern, or a combination of the patterns, may be desired, and the spray pattern of the sprinkler will be structured accordingly.

One mechanism for shaping the spray pattern, and hence the circulation pattern, is through the shape and arrangement of spaced apart tines located about the periphery of the deflector. The tines of an upright deflector, which are normally angled to face towards the outlet of the sprinkler, tend to deflect water downwardly to fill in the area beneath the sprinkler. The angle, size and shape of the tines predominantly affect the pattern of the downwardly deflected water. The water passing radially outward through the spaces or openings between the tines predominantly forms the outer portion of the spray pattern.

One of the purposes of this invention is to provide substantially improved uniformity of the water distribution pattern for sprinklers such as ECOH upright type sprinklers, thereby decreasing the variability in fire protection performance as a function of fire location, within the protected area.

The variabilities of building construction sometimes make it necessary to space sprinklers much closer together than their maximum permitted spacings, in order to provide the required degree of protection around obstructions such as columns or partitions. However, as sprinklers are brought closer together, there is an increased tendency of the spray from an operating sprinkler to impinge on an adjacent sprinkler which has not yet operated; thereby wetting the

thermally responsive element of the adjacent sprinkler and preventing its proper or timely operation. If this condition, known as "cold soldering", occurs, it could lead to the fire progressing past the wetted element sprinkler, thereby increasing the damage caused by the fire. Consequently, organizations which list sprinklers include a cold soldering test in their product evaluation.

Sprinklers listed for use with a maximum standard coverage area of 130 $ft^2$ for ordinary hazard classified occupancies, as defined by NFPA 13, are required to be able to be located as close as 6 ft apart without the occurrence of cold soldering. The maximum sprinkler spacing for the 130 $ft^2$ coverage area is 10 ft by 13 ft.

In the case of an extended coverage sprinkler such as an ECOH upright type sprinkler, it is difficult to design a unit which will not result in cold soldering at a spacing as low as 9 ft yet provide the umbrella shaped water spray pattern which is necessarily high enough and wide enough to allow use of the sprinklers at a maximum spacing of 20 ft by 20 ft (i.e., coverage area of 400 $ft^2$).

An additional purpose of this invention is to provide an upright type sprinkler deflector design which is capable of providing a 20 ft by 20 ft maximum spacing coverage capability in combination with a minimum spacing capability of 9 ft without sacrifice of the desired uniformity of the spray pattern over the entire protected area.

Another concern in the development of automatic fire sprinklers is providing the water distribution performance necessary for that portion of the protected area furthest from any sprinkler. As specified in NFPA 13, sprinklers having frame arms, which is typical of the upright type, are to be installed with the plane of the sprinkler frame arms parallel to the pipe on which they are installed.

If the sprinklers are installed in a square pattern (which generally minimizes the number of sprinklers that must be installed to protect a large, relatively open space), the point centered between the four sprinklers (i.e., 45° from the plane of the frame arms) is furthest away from any of the sprinklers. The center point of this geometry is a distance of about 1.41 times one-half the sprinkler spacing away from any of the sprinklers. This is the worst case distance in terms of the "throw" necessary to ensure that sufficient water is distributed over the entire area to be protected, without spraying water too far out in other areas.

In this regard, it is also a feature of this invention to provide increased water collection in the central portion of the protected area furthest from four sprinklers, such as the ECOH upright type, installed in a square array, without sacrifice of the desired uniformity of the spray pattern over the entire protected area.

Extended coverage/ordinary hazard rated sprinklers are required to provide the same rates of water collection per unit area (i.e., density in terms of gpm/$ft^2$ (gallons per-minute/square foot) as standard coverage/ordinary hazard sprinklers, over the increased coverage area. NFPA 13 requires that sprinklers provide an average density of either 0.15 gpm/$ft^2$ or 0.20 gpm/$ft^2$ over the coverage area, depending on whether the commodity being protected is classified as Ordinary Hazard Group 1 or Ordinary Hazard Group 2, respectively, assuming a sprinkler operation design area of 1500 $ft^2$. Thus, to cover the maximum allowable standard coverage area of 130 $ft^2$ for Ordinary Hazard Group 2, a minimum flow of 26 gpm per sprinkler over the sprinkler operation design area is required. However, to cover the maximum allowable extended coverage area of 400 $ft^2$ per NFPA 13, 80 gpm is required. It is a natural and well understood principle that the much higher flow requirements for ECOH sprinklers require use of a sprinkler with a waterway larger than that commonly used for standard coverage/ordinary hazard application sprinklers.

The flow "Q" from a sprinkler expressed in U.S. gallons per minute (gpm) is determined by the formula:

$$Q=K\,(p)^{1/2}$$

where "K" represents the nominal sprinkler discharge coefficient, normally referred to as "K-factor", and "p" represents the residual (flowing) pressure at the inlet to the sprinkler in pounds per square inch (psi). In standard coverage/ordinary hazard applications, the most commonly used sprinklers have K-factors of about 5.6 (standard orifice) or 8.0 (large orifice). However, in extended coverage/ordinary hazard applications, sprinklers having K-factors of about 11.2 (extra large orifice) or 14.0 (very extra large orifice) are commonly used.

The use of the larger K-factors for ECOH applications reduces the required residual (flowing) pressure at the sprinkler inlet. This is advantageous, since generation of the higher pressure will require more power. In addition to lowering the minimum required residual (flowing) pressure over the sprinkler operation design area, the use of extra large and very extra large sprinklers provides another well understood advantage. That is, as the residual (flowing) pressure is lowered, there is an increase in the size of the water droplets created by the water stream emitted from the sprinkler orifice striking the sprinkler deflector as well as that portion of each sprinkler frame arm falling within the water stream. These larger water droplets have a higher momentum, which assists in penetration of the upward draft which can be created by a fire. In addition, the higher momentum water droplets can be deflected further from the sprinkler, as desired for extended coverage performance capability.

It is noted that using ECOH sprinklers with higher K-factors is not necessarily an advantage in all circumstances. For example, if the coverage area is 14 ft by 14 ft and the commodity is rated as Ordinary Hazard Group **1**, a minimum flow of only 29.4 gpm per sprinkler is required. This would mean that the minimum required residual (flowing) pressure at the inlet of a 14.5 K-factor sprinkler would be only 4.1 psi. Use of such a low pressure could be of concern with respect to ensuring that the operating parts of the sprinkler are properly ejected when the thermally responsive element releases. This concern has been recognized by the National Fire Protection Association, and it is expected that the 1996 edition of NFPA 13 will be revised to require that all sprinkler systems be designed to operate any sprinkler at a minimum residual (flowing) pressure of 7 psi.

The features of the present invention may be used in 11.4 and 14.5 K-factor upright ECOH sprinklers. However, the advantages provided are not limited to the higher K-factor sprinklers and, for example, they could be used with nominally 5.6 or 8.0 K-factor sprinklers.

Other features and advantages of the invention will be apparent from the following description of a presently preferred embodiment, and from the claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side view of an upright fire protection sprinkler with a deflector of the invention;

FIG. **2** is a side section view of the body of the upright fire protection sprinkler taken along the line **2**—**2** of FIG. **1**; and

FIG. 3 is a top plan view of the deflector of the invention on the upright fire protection sprinkler, taken along the line 3—3 of FIG. 1.

FIG. 4 is a top plan view of a blank for forming a deflector of the invention, prior to bending; and

FIG. 5 is a side section view of the blank, taken along the line 5—5 of FIG. 4.

FIG. 6 is a side section view of the deflector, taken along the line 6—6 of FIG. 3;

FIG. 7 is a similar side section view of the deflector, taken along the line 7—7 of FIG. 3; and

FIG. 8 is another side section view of the deflector, taken along the line 8—8 of FIG. 3.

FIG. 9 is a somewhat diagrammatic plan view of the under-surface of a deflector of the invention showing spray regions.

FIG. 10 shows spray densities achieved in a test of an upright fire protection sprinkler with a deflector of the invention; and

FIG. 11 shows spray densities achieved in a test of the same upright fire protection sprinkler but with a deflector which does not have the recessed central area of a deflector of this invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1–3, this invention concerns a fire protection sprinkler device **10** of the upright type, including a body **12** having an outlet **14** and an orifice **16**, with a releasable plug **18** normally closing the outlet and securing it in a sealed condition, a thermally responsive element **20** normally retaining the plug **18** in the closed position, and a water distribution deflector **22** facing the orifice. The orifice **16** that determines the K-factor of the sprinkler is normally located just upstream of the outlet **14**. An upright type sprinkler **10** is one that is installed in such a way that the water stream discharged from the outlet **14**, following release of the thermally responsive element **20**, is directed upwards against a distribution plate that is normally referred to as a deflector **22**, typically mounted to sprinkler mounting boss **26**, supported by frame arms **28**, **30**. In the case of an upright type sprinkler of the standard spray variety, the deflector **22** redirects and distributes the water downward as well as outward over the area to be protected.

A deflector **22** of the invention for use with 11.4 and 14.5 K-factor upright fire protection sprinklers, e.g., of the type to be sold by Grinnell Corporation, of Exeter, New Hampshire, under the Model F895 ECOH designation, is shown in FIG. 3 and in FIGS. 6–8. The deflector **22** is formed from a blank **24**, shown in FIGS. 4 and 5.

Referring now also to FIGS. 6–8, the deflector **22** has an inner surface **23** opposed to flow of water from the outlet **14** and an opposite, outer surface **25**. The inner surface **23** of deflector **22** defines a central area **32** that is recessed, i.e. spaced further away, from the outlet **14** relative to a radially outwardly disposed base area **27** of the deflector surface, the recessed central region **32** being disposed generally perpendicular to the axis, A, of the sprinkler body **12**. A similarly recessed redirecting surface **34**, essentially free of openings through to the outer surface **25** of the defector, surrounds the recessed central area **32** of the deflector **22**, at a predetermined angle, $A_R$, and depth, $D_R$, thereto, where it is impinged by the water stream discharged from the sprinkler orifice **16**.

The shape of the deflector **22** of the invention creates a substantially more uniform and optimized spray pattern for large (extended coverage) areas, as compared to prior art deflectors, as will now be described more fully.

Referring to FIGS. 1–9, when a water stream emitted from the orifice **16** and through the sprinkler outlet **14** strikes the deflector mounting boss **26** and frame arms **28**, **30** attached at either side of the deflector mounting boss, the water tends to break off (separate), and then impinge on the deflector **22** in a pattern as schematically shown in FIG. **9**. As a result, there tend to be stronger velocity components perpendicular to and parallel to the plane, $P_F$, of the frame arms, as shown by the direction of the arrows, $W_1$.

The effect of this non-uniform velocity profile is to produce a spray distribution pattern which is dominant (heaviest) in directions along the plane, $P_F$, of the frame arms **28**, **30** and perpendicular to the plane, $P_P$. The velocity component at 45° to the plane of the frame arms tends to be somewhat weaker. This creates a particular problem for ECOH sprinklers, since this area at 45° is furthest away from the sprinkler, when installed in a square array.

To improve the uniformity of the velocity profile, the recessed redirecting surface **34** has been conceived. The recessed redirecting surface surrounds the recessed central area **32** of the deflector **22** impinged by the water stream discharged from the sprinkler orifice **16**. This recessed redirecting surface **34** captures and redirects the water impinging upon it, thereby increasing the velocity component at 45° to the plane, $P_F$, of the frame arms **28**, **30**. The velocity components of the water spray in the directions along the plane, $P_F$, of the frame arms and in the plane, $P_P$, perpendicular thereto are, therefore, reduced. By this means, the overall uniformity of the water spray pattern over the area to be protected by the sprinkler is improved substantially.

The angle, $A_R$, of the recessed redirecting surface **34**, located around the perimeter of the recessed central area **32** of the deflector, is an important aspect of providing this function. The recessed redirecting surface **34** should not be excessively vertical, because it will then direct too much of the water directly downward. In addition, a recessed redirecting surface **34** that is vertical could tend to capture one or more of the operating parts of the sprinkler **10**, which might then be held by the water stream against the deflector surface, thereby obstructing portions of the water distribution pattern. The depth, $D_R$, of the recessed redirecting surface is also important. An excessively deep recessed redirecting surface **34** will tend to cause an excessive amount of water to be distributed directly beneath the sprinkler. The recessed redirecting surface **34** of the invention has an angle, $A_R$, in the range of about 10° to 45°, and preferably about 22° to 32°, relative to the horizontal, and a depth, $D_R$, in the range of about 0.030 inch to 0.210 inch, and preferably about 0.090 to 0.150 inch. In the preferred embodiment, the angle, $A_R$, of recessed redirecting surface **34** is nominally 27° relative to the horizontal, and the depth, $D_R$, is about 0.120 inch. This has been shown to function ideally for both 11.4 and 14.5 K-factor orifice ECOH upright-type sprinklers.

Another feature of the deflector **22** of the invention involves minimizing overspray from an operating sprinkler towards adjacent sprinklers. In a typical sprinkler system installation, adjacent sprinklers are located on both perpendicular axes associated with planes $P_F$, $P_P$. As a general case, experience has demonstrated that these directions are usually of primary concern in terms of water spraying onto the thermally responsive element **20** of adjacent sprinklers (i.e., cold soldering). This is of particular concern with ECOH

sprinklers, since they are designed to spray further outward than ordinary hazard classified standard coverage sprinklers.

In the described invention, minimizing the possibility of overspray from an operating sprinkler **10** towards adjacent sprinklers, along the ceiling, is accomplished by specifically locating two pairs of tines, **40, 40'** and **42, 42'** positioned at the periphery of the deflector with inner surfaces inclined towards the outlet **14**, and located respectively along the directions in line with the plane, $P_F$, of the frame arms and in the plane, $P_P$, perpendicular thereto. (Within the present state of the art, tines may or may not be positioned in these locations for commonly available upright-type sprinklers.)

According to the invention, the width of the tines **42, 42'** located along the direction of the plane, $P_P$, perpendicular to the plane of the frame arms **28, 30**, and inclined toward the outlet **14**, have a predetermined width, $W_P$, e.g. from about 0.050 inch to 0.250 inch wide, preferably about 0.100 inch to 0.200 inch wide, and more preferably about 0.150 inch wide. Tines **42, 42'** located in these positions and having the preferred width have been shown to effectively preclude overspray in the direction perpendicular to the plane of the frame arms. The tines **40, 40'** located along the plane, $P_F$, of the frame arms have a relatively smaller predetermined width, $W_F$, e.g. from about 0.15 to 0.65 times, and preferably about 0.30 to 0.50 times, the width, $W_P$, of the tines **42, 42'** located along the direction of the plane, $P_F$, of the frame arms. In the preferred embodiment, the predetermined width, $W_F$, is about 0.40 times the width, $W_P$, of the tines **42, 42'** located along the plane, $P_F$, of the frame arms, or about 0.060 inch wide. The tines **40, 40'** located in these positions cooperate with the frame arms **28, 30** to produce a spray pattern which is not sprayed excessively far out in the direction of the plane, $P_F$, of the frame arms.

Referring to FIGS. **7** and **8**, another feature of the deflector **22** of the invention involves use of tines **44, 45, 46, 47** positioned at the periphery of the deflector **22** and located at 45° to the plane, $P_F$, of the frame arms. These tines provide further control for optimizing distribution of water in these critical directions. By locating tines in these positions, and by orienting them with inner surfaces inclined in a more outward direction (i.e. away from vertical) than the inner surfaces of other tines, more water can be distributed both outwardly and downwardly in these directions. (Within the present state of the art, it is customary to have all of the tines of an upright-type sprinkler deflector oriented at the same angle to vertical.) In the deflector of the invention, the inner surfaces of tines **44, 45, 46, 47** are disposed at a predetermined angle, $A_T$, further from the vertical than the predetermined angle, $A_S$, of the inner surfaces of adjacent tines. In the preferred embodiment, the angular difference from the vertical is about 10° to 45°, and preferably about 22° to 33°, and more preferably about 27°30'.

According to one preferred embodiment, the deflector blank has an outer diameter of about 2.10 inches with a diameter between tines of about 1.84 inches. After bending, the diameter, $O_M$, is about 1.92 inches, the outer diameter, $O_S$, at the tines 45° to the plane, $P_F$, of the frame arms **28, 30** is about 1.99 inches, and the diameter, $O_B$, between the tines is about 1.76 inches. The diameter, $O_{T1}$, between the bases of tines **44, 46** is about 1.84 inches and the same for the remainder of the twenty-four tines. The diameter, $O_{T2}$, between the bases of tines **42, 42'** is also about 1.84 inches. The diameter, $O_C$, of the recessed central area **32** is about 0.92 inch. The outer diameter, $O_R$, of the recessed redirecting area **34** is about 1.35 inches. Tines **44, 45, 46** and **47** are about 0.074 inch wide. The remaining tines (excluding tines **40, 40'** and **42, 42'**, discussed above) are about 0.060 inch wide. $A_T$ is 55°±3° and $A_S$ is 27°30'±1°30'. The outer surface **25** of the deflector in the region **50** of the recessed central area **32** has a flat inward region **52** having a diameter, $O_F$, e.g. about 0.44 inch, and an outward region **54** sloping towards the sprinkler outlet at an angle, $A_C$, e.g. about 2°30'±1° from the horizontal.

An outward distribution of water from the sprinkler is particularly important in the case where there is relatively little clearance between the commodity and the sprinkler deflector (as low as 18 inches is permitted by NFPA 13). (As a matter of reference, downward distribution becomes more important with greater clearance between the sprinkler deflector and commodity, in order to ensure that sufficient water is driven down into the fire plume. Thus, it is essential that both of these attributes be provided in the same sprinkler.)

With larger coverage areas, a fire centered between four sprinklers can result in a somewhat slower thermally activated release of ECOH sprinklers, as compared to sprinklers installed in accordance with standard coverage spacing requirements. This means that a fire may grow somewhat larger prior to sprinkler operation and that the associated fire plume can generate greater upward velocity, which will tend to lift the spray pattern and reduce penetration of water droplets onto the burning surfaces. Thus, if the deflector provides a predominantly outwardly directed pattern at the 45° location, the spray pattern may be lifted to the point of reducing spray effectiveness. Consequently, it is necessary for water distribution characteristics of an ECOH sprinkler to be well balanced, both downwardly and outwardly, over the area to be protected.

Referring now to FIGS. **10** and **11**, the effect of one feature of a deflector **22** of the invention is illustrated. In particular, the recessed redirecting surface **34** changes the characteristics of the spray pattern from being dominant in directions parallel and perpendicular to the plane, $P_F$, of the frame arms **28, 30** to a pattern in which the density in the area located at 45° to the frame arms is substantially increased.

FIG. **10** represents the spray pattern for a 14.5 K-factor sprinkler with a deflector **22** of the invention. The spray density at an elevation of 3 ft below the deflector is shown. Each box represents a 1 $ft^2$ area, with the numbers indicating gallons per minute in that area. A quadrant of the pattern in a 20 ft by 20 ft area is shown. Four sprinklers **10** spaced 20 ft apart are discharging at 60 gpm with the flow to the sprinkler directed as shown in the figure. Nominal average density over the 20 ft by 20 ft area will be slightly higher than 0.15 gpm/$ft^2$ because of the tee effect. That is, water passing from the pipe through the tee and orifice tends to bend slightly towards the direction from which the water is flowing and this tends to create slight non-uniformity in the overall distribution pattern such that the area between four sprinklers receives more water than that expected if the distribution is absolutely uniform.

FIG. **11** represents the spray pattern for an identical sprinkler **10'** to that represented by FIG. **10** except that the deflector is flat. Tine location, size and angles are otherwise identical. Thus the differences in the distribution patterns between FIG. **10** and FIG. **11** are due to the recessed redirecting surface **34** of the deflector represented by FIG. **10**. In FIG. **10**, note that the average spray density of 0.163 gpm/$ft^2$ in the area at 45° to the frame arms is about 12% higher than that of 0.145 gpm/$ft^2$ for the equivalent area in FIG. **11**. Thus, water from the areas perpendicular and parallel to the frame arms has been redirected towards the central area of the pattern between four sprinklers.

It is noted that UL requires that the central area, C, of the pattern must average 0.150 gpm/ft$^2$ when tested in the configuration of FIGS. 10 and 11. Thus while the deflector 22 with the redirecting surface 34 easily meets the UL requirement, the flat deflector fails to meet the required average.

It is noted that UL also conducts so-called 350 pound wood crib fire tests with 7 foot, 6 inches of clearance between the sprinkler deflector and the top surface of the wood crib. In this test, an n-heptane fuel burner is located underneath the wood crib and provides a fire of approximately 2 megawatts which generates a strong upward plume. These tests are conducted between four sprinklers spaced in accordance with each coverage area for which the sprinkler is to be UL Listed. The performance of the ECOH upright-type sprinklers of the present invention was exceptionally good in all of these test scenarios.

Other embodiments of the invention are within the scope of the following claims.

What is claimed is:

1. An upright fire protection sprinkler comprising a body defining an orifice and outlet for flow of fluid from a source, said outlet having an axis, and a deflector disposed generally coaxial with said outlet and positioned for impingement of the flow of fluid thereupon,

said deflector defining an inner surface opposed to water flow from said outlet and positioned for impingement of flow of fluid thereupon, and an opposite outer surface,

said inner surface defining:

a generally planar central area about said axis,

a redirecting area extending about the periphery of said central area at a predetermined acute angle and predetermined axial offset thereto, relative to the horizontal, said redirecting area being free of through openings from said inner surface of said deflector to said opposite outer surface, and

a base area radially outward of and extending about the periphery of said redirecting area, at least an inner region of said base area being free of through openings,

said central area and said redirecting area being recessed from said outlet relative to said base area, said base area lying in a plane perpendicular to said axis.

2. The upright fire protection sprinkler of claim 1 wherein said predetermined acute angle is between about 10° to 45°.

3. The upright fire protection sprinkler of claim 2 wherein said predetermined acute angle is between about 22° to 32°.

4. The upright fire protection sprinkler of claim 3 wherein said predetermined acute angle is about 27°.

5. The upright fire protection sprinkler of claim 1 wherein said predetermined axial offset of said redirecting area, relative to the horizontal, as measured between intersections of said redirecting area with said central area and said base area, is between about 0.030 inch and 0.210 inch.

6. The upright fire protection sprinkler of claim 5 wherein said predetermined axial offset is between about 0.090 inch and 0.150 inch.

7. The upright fire protection sprinkler of claim 6 wherein said predetermined axial offset is about 0.120 inch.

8. The upright fire protection sprinkler of claim 1 further comprising a pair of frame arms extending from said body and disposed generally in a first plane including said axis, with said deflector mounted thereupon, said deflector further comprising a plurality of tines defining inner tine surfaces inclined, relative to the horizontal, towards said outlets, said plurality of tines comprising at least a first set of tines and a second set of tines.

9. The upright fire protection sprinkler of claim 8 wherein said first set of tines are disposed in planes at about 45° to said first plane and including said axis, said inner tine surfaces of said first set of tines being inclined at a first predetermined angle from the horizontal, and, adjacent to said first set of tines, said plurality of tines further comprises tines having said inner tine surfaces inclined at a second predetermined angle from the horizontal, said first predetermined angle being relatively more outward from said axis than said second predetermined angle.

10. The upright fire protection sprinkler of claim 9 wherein said first predetermined angle is between about 10° to 45° further from the vertical than said second predetermined angle.

11. The upright fire protection sprinkler of claim 10 wherein said first predetermined angle is between about 22° to 33° further from the vertical than said second predetermined angle.

12. The upright fire protection sprinkler of claim 11 wherein said first predetermined angle is about 27°30' further from the vertical than said second predetermined angle.

13. The upright fire protection sprinkler of claim 8 wherein a second set of tines generally in a plane perpendicular to said first plane have a predetermined second set width and a third set of tines in said first plane including said frame arms has a predetermined third set width, said predetermined third set width being about 0.15 to 0.65 times said predetermined second set width.

14. The upright fire protection sprinkler of claim 13 wherein said predetermined third set width is about 0.30 to 0.50 times said predetermined second set width.

15. The upright fire protection sprinkler of claim 14 wherein said predetermined third set width is about 0.40 times said predetermined second set width.

16. The upright fire protection sprinkler of claim 15 wherein said predetermined second set width is about 0.150 inch and said predetermined third set width is about 0.060 inch.

17. The upright fire protection sprinkler of claim 8 wherein said second set of tines are disposed generally in a plane perpendicular to said first plane and including said axis, said inner tine surfaces of said second set of tines having a predetermined second set width, said predetermined second width being substantially greater than widths of said inner tine surfaces of all other tines of said plurality of tines.

18. The upright fire protection sprinkler of claim 17, wherein said predetermined second width is about 0.150 inch.

19. An upright fire protection sprinkler comprising:

a body defining an orifice and outlet for flow of fluid from a source, said outlet having an axis,

a deflector disposed generally coaxial with said outlet and positioned for impingement of the flow of fluid thereupon, and

a pair of frame arms extending from said body and disposed generally in a first plane including said axis, with said deflector mounted thereupon,

said deflector comprising a plurality of tines defining inner tine surfaces inclined from the horizontal towards said outlet, said plurality of tines comprising at least a first set of tines, said first set of tines being disposed in planes at about 45° to said first plane and including said axis, said inner tine surfaces of said first set of tines being inclined at a first predeter-

mined angle from the horizontal, and, adjacent to said first set of tines, said plurality of tines further comprises tines having said inner tine surfaces inclined at a second predetermined angle from the horizontal, said first predetermined angle being relatively more outward from said axis than said second predetermined angle.

20. The upright fire protection sprinkler of claim 19 wherein said first predetermined angle is between about 10° to 45° further from the vertical than said second predetermined angle.

21. The upright fire protection sprinkler of claim 20 wherein said first predetermined angle is between about 22° to 33° further from the vertical than said second predetermined angle.

22. The upright fire protection sprinkler of claim 21 wherein said first predetermined angle is about 27°30' further from the vertical than said second predetermined angle.

23. The upright fire protection sprinkler of claim 19, 20, 21 or 22 wherein said deflector further defines an inner surface opposed to water flow from said outlet and positioned for impingement of flow of fluid thereupon, and an opposite outer surface,

said inner surface defining:

a generally planar central area about said axis,

a redirecting area extending about the periphery of said central area at a predetermined acute angle and predetermined axial offset thereto, relative to the horizontal, said redirecting area being free of through openings from said inner surface of said deflector to said opposite outer surface, and

a base area radially outward of and extending about the periphery of said redirecting area, at least an inner region of said base area being free of through openings,

said central area and said redirecting area being recessed from said outlet relative to said base area.

24. An upright fire protection sprinkler comprising:

a body defining an orifice and outlet for flow of fluid from a source, said outlet having an axis,

a deflector disposed generally coaxial with said outlet and positioned for impingement of the flow of fluid thereupon, and

a pair of frame arms extending from said body and disposed generally in a first plane including said axis, with said deflector mounted thereupon,

said deflector comprising a plurality of tines defining inner tine surfaces inclined from the horizontal towards said outlet,

said plurality of tines comprising at least a first set of tines, a second set of tines, and a third set of tines, said second set of tines being disposed generally in a plane perpendicular to said first plane and including said axis, and said third set of tines being disposed in said first plane including said frame arms, said inner tine surfaces of said second set of tines having a predetermined second set width extending across said plane perpendicular to said first plane and including said axis, and said inner tine surfaces of said third set of tines having a predetermined third set width, said predetermined third set width being about 0.15 to 0.65 times said predetermined second set width.

25. The upright fire protection sprinkler of claim 24 wherein said predetermined third set width is about 0.30 to 0.50 times said predetermined second set width.

26. The upright fire protection sprinkler of claim 25 wherein said predetermined third set width is about 0.40 times said predetermined second set width.

27. The upright fire protection sprinkler of claim 26 wherein said predetermined second set width is about 0.150 inch and said predetermined third set width is about 0.060 inch.

28. The upright fire protection sprinkler of claim 24, 25, 26 or 27 wherein said deflector further defines an inner surface opposed to water flow from said outlet and positioned for impingement of flow of fluid thereupon, and an opposite outer surface,

said inner surface defining:

a generally planar central area about said axis,

a redirecting area extending about the periphery of said central area at a predetermined acute angle and predetermined axial offset thereto, relative to the horizontal, said redirecting area being free of through openings from said inner surface of said deflector to said opposite outer surface, and

a base area radially outward of and extending about the periphery of said redirecting area, at least an inner region of said base area being free of through openings,

said central area and said redirecting area being recessed from said outlet relative to said base area.

29. An upright fire protection sprinkler comprising:

a body defining an orifice and outlet for flow of fluid from a source, said outlet having an axis,

a deflector disposed generally coaxial with said outlet and positioned for impingement of the flow of fluid thereupon, and

a pair of frame arms extending from said body and disposed generally in a first plane including said axis, with said deflector mounted thereupon,

said deflector comprising a plurality of tines defining inner tine surfaces inclined from the horizontal towards said outlet,

said plurality of tines comprising at least a first set of tines and a second set of tines, said second set of tines being disposed generally in a plane perpendicular to said first plane and including said axis, said inner tine surfaces of said second set of tines having a predetermined second set width extending across said plane perpendicular to said first plane and including said axis, said predetermined second set width being substantially greater than widths of said inner tine surfaces of all other tines of said plurality of tines.

30. The upright fire protection sprinkler of claim 29, wherein said predetermined second width is about 0.150 inch.

31. The upright fire protection sprinkler of claim 29 or 30 wherein said deflector further defines an inner surface opposed to water flow from said outlet and positioned for impingement of flow of fluid thereupon, and an opposite outer surface,

said inner surface defining:

a generally planar central area about said axis,

a redirecting area extending about the periphery of said central area at a predetermined acute angle and predetermined axial offset thereto, relative to the horizontal, said redirecting area being free of through openings from said inner surface of said deflector to said opposite outer surface, and

a base area radially outward of and extending about the periphery of said redirecting area, at least an inner region of said base area being free of through openings,

said central area and said redirecting area being recessed from said outlet relative to said base area.

32. The upright fire protection sprinkler of claim **1, 19, 24,** or **29**, wherein said sprinkler has a K-factor of at least 5.0.

33. The upright fire protection sprinkler of claim **32**, wherein said sprinkler has a K-factor of at least 7.0.



34. The upright fire protection sprinkler of claim **33**, wherein said sprinkler has a K-factor of at least 10.5.

35. The upright fire protection sprinkler of claim **34**, wherein said sprinkler has a K-factor of at least 13.0.

* * * * *

US005505383A

# United States Patent [19]

Fischer

[11] Patent Number: 5,505,383

[45] Date of Patent: Apr. 9, 1996

## [54] FIRE PROTECTION NOZZLE

[75] Inventor: Michael A. Fischer, West Kingston, R.I.

[73] Assignee: Grinnell Corporation, Cranston, R.I.

[21] Appl. No.: 333,523

[22] Filed: Nov. 2, 1994

[51] Int. Cl.$^{6}$ .................................................. A62C 31/02

[52] U.S. Cl. .............................................. 239/518; 169/37

[58] Field of Search .................................. 239/518, 524, 239/512, 506, 515; 169/37–41, 90

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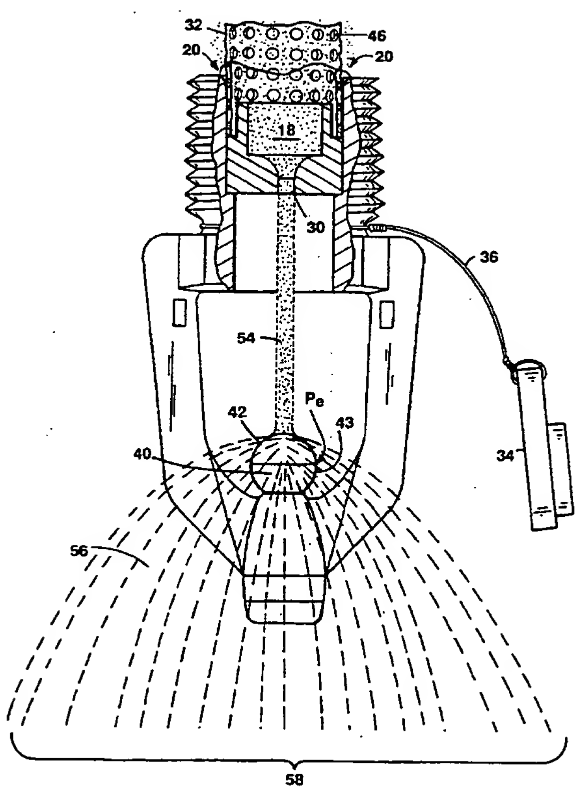
*Primary Examiner*—Karen B. Merritt

*Attorney, Agent, or Firm*—Fish & Richardson

[57] ABSTRACT

A fire protection nozzle has a base, an orifice, defined by the base and having a predetermined diameter, through which fire-retardant fluid can flow, a inlet section having an upstream end and defining a conduit for flow of the fire-retardant fluid along a conduit axis and leading to an upstream end of the orifice, a diffuser element positioned coaxially with and downstream of the orifice, and one or more arms extending from the base and supporting the diffuser element in a position, where, when flow of the fire-retardant fluid from the inlet section through the orifice is established, the fire-retardant fluid emerges from the orifice in a stream which impinges on a diffuser surface defined by the diffuser element to be distributed in a spray pattern. The diffuser surface defined by the diffuser element is generally spherical in shape in a region extending from an upstream end closest to the orifice to at least downstream of an equatorial plane of the diffuser element transverse to the conduit axis.

**13 Claims, 3 Drawing Sheets**



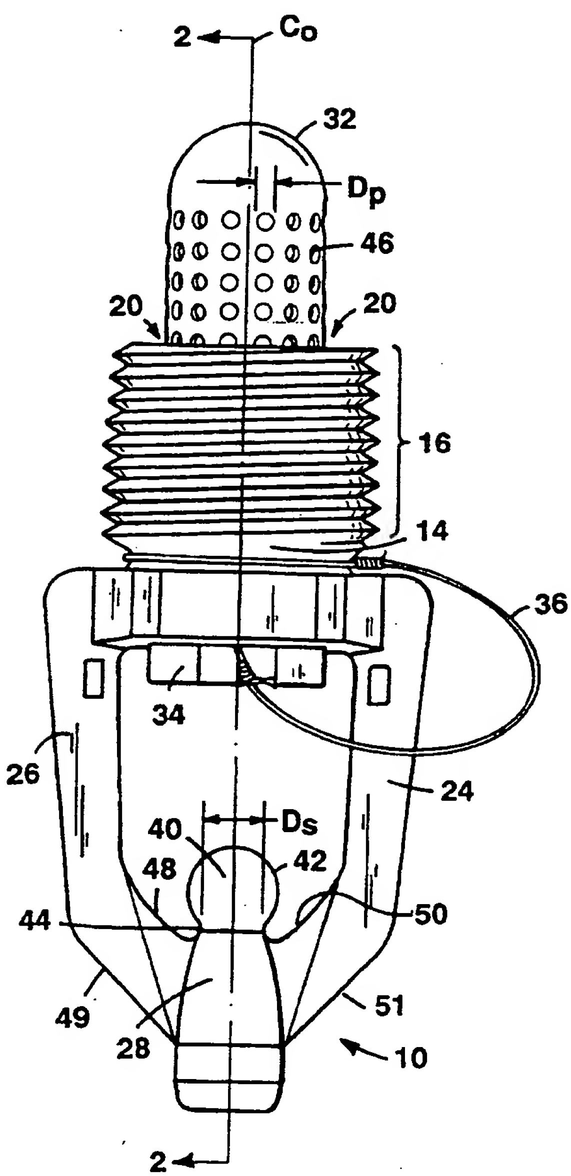

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FIG. 1

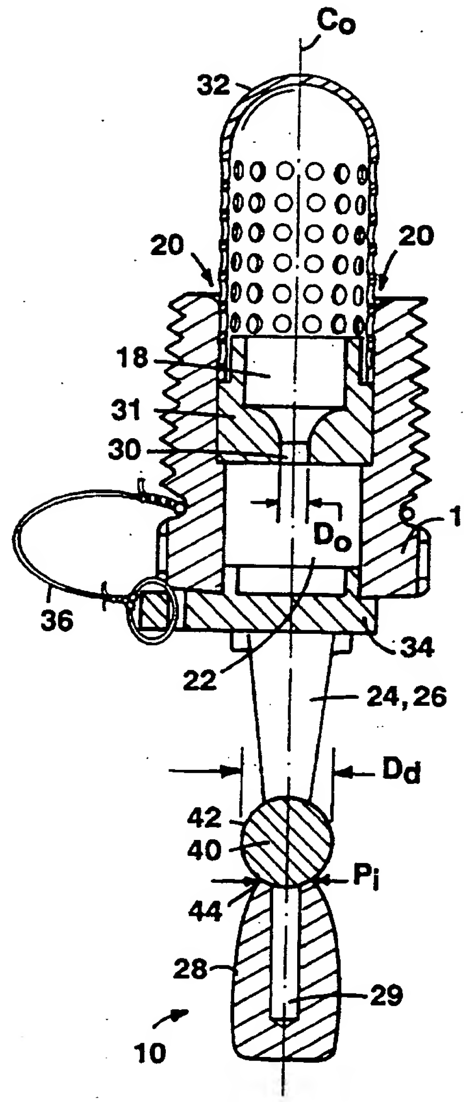
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FIG. 2

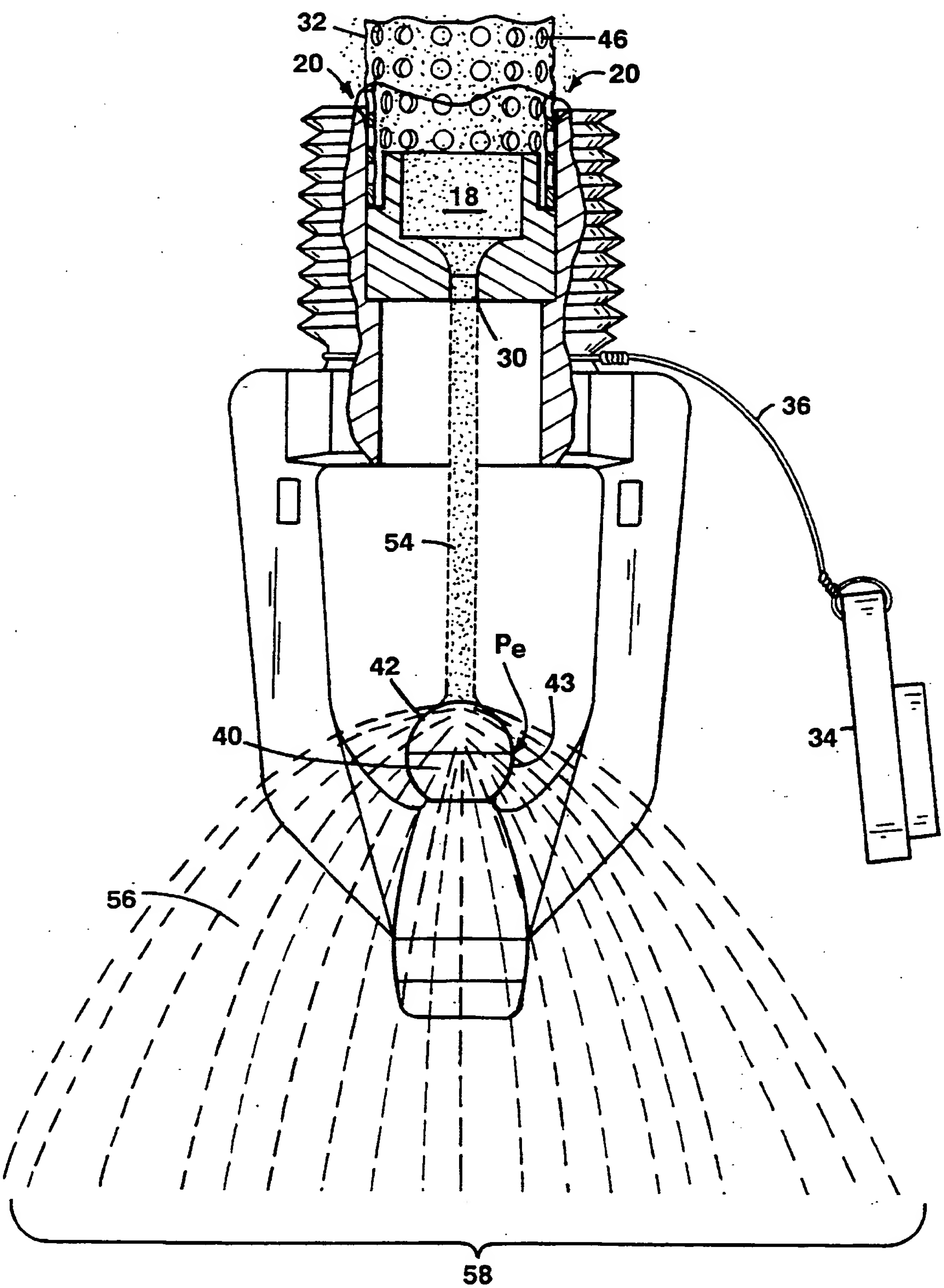


FIG. 3

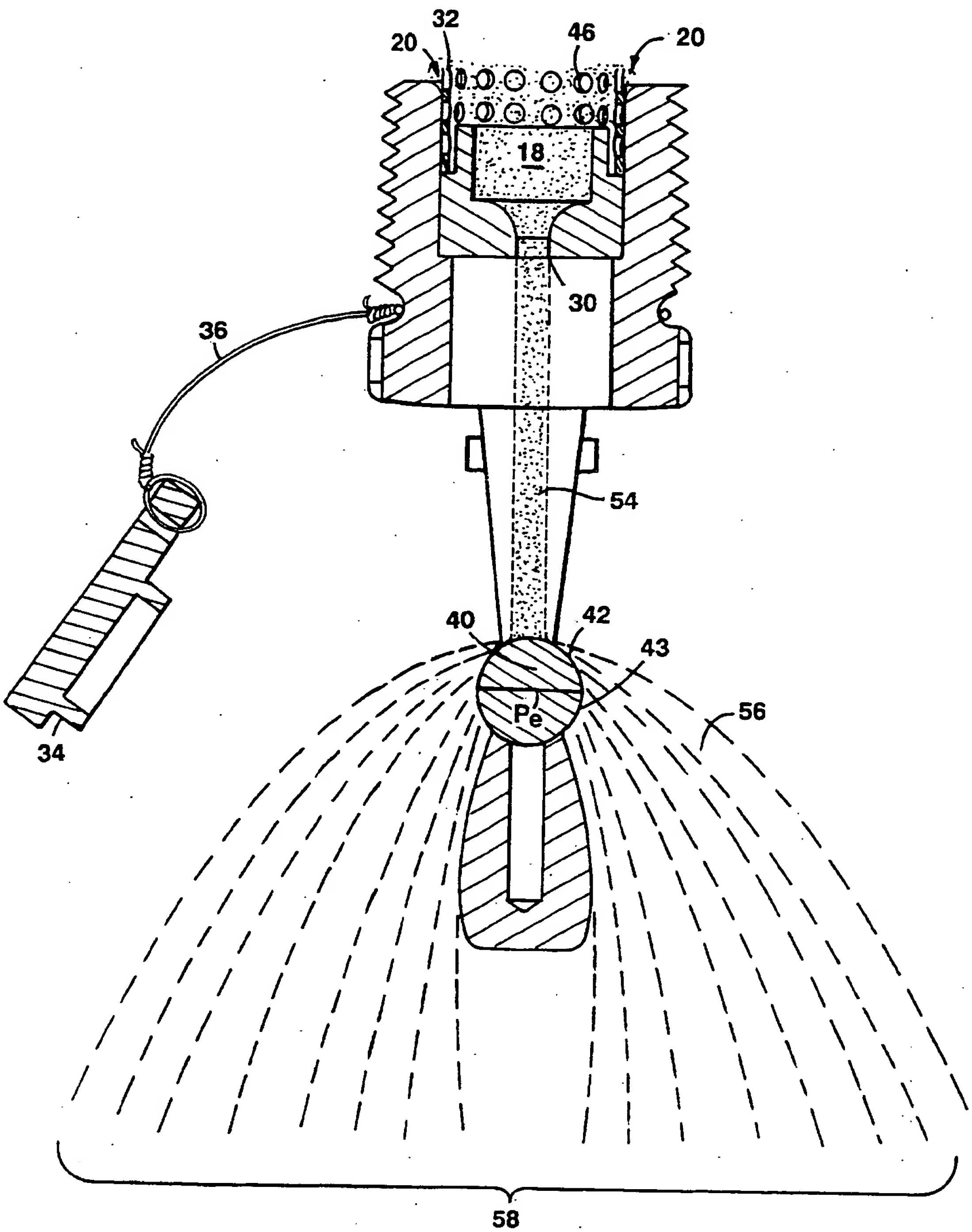


FIG. 4

# FIRE PROTECTION NOZZLE

## FIELD OF THE INVENTION

This invention relates to manually and automatically operated nozzle systems for discharging fire-retardant fluids.

## BACKGROUND OF THE INVENTION

Certain types of fire protection nozzles are used to discharge water, with or without additives, in a relatively fine spray, which is generally referred to in the industry as mist.

The mechanism by which a fine spray (water mist) nozzle system acts to control, suppress or extinguish a fire can be a complex combination of two or more of the following factors, depending on the class(es) of the combustible materials involved, the operating concept of the individual nozzle, the size of the orifice(s), the operating pressure and the flow rate:

(1) Heat extraction from the fire as water is converted into vapor and the fuel is cooled;

(2) Reduced oxygen levels as the water vapor displaces oxygen near the seat of the fire;

(3) Dilution of flammable vapors by the entrainment of water vapor to such an extent that the resultant mixture of vapors will not burn;

(4) Enveloping of the protected area to pre-wet adjacent combustibles, cool gases and other fuels in the area and block the transfer of radiant heat to adjacent combustibles; and/or

(5) Direct impingement wetting and cooling of the combustibles.

In the case of Class A combustibles, a combination of factors (1), (2), (4) and/or (5) may be involved, while a combination of factors (1), (2) and/or (3) may be involved in the case of Class B fires. In order to prevent the electrical conductivity of water from representing a potential problem, the extinguishment of Class C fires by fine water mist is generally limited to nozzle systems which primarily depend on factors (1) and/or (2) only.

It is generally acknowledged that in order for water spray to be described as mist-like, the majority of the water droplets should have a diameter of less than 500 microns (0.020 inch).

However, in the case of Class B fires, the majority of the droplets should have a diameter of less than 300 microns (0.012 inch) in order to maximize the effects of factors (1), (2) and/or (3). In the case of Class C fires, the majority of the water droplets should have a diameter less than 200 microns (0.008 inch) in order to maximize the effects of factors (1) and/or (2) at the smallest practical fire size. In the case of Class A fires, the mist-like droplets may be intentionally combined with a small percentage of high momentum large droplets, in the order of up to 1500 microns (0.060 inch), which serve to entrain and drag the mist-like droplets into the combustion zone, as well as provide some direct impingement wetting and cooling of the combustibles.

Various types of nozzles discharging a fine water spray have long been used in fire protection systems. Although often not described as such at the time, perforated diffuser sprinklers, e.g. as described in Parmalee U.S. Pat. No. 6,275, discharged water in a fine spray by nature of the diffuser holes being in the order of 0.06 inch in diameter. Other examples of fine spray nozzle designs intended for use in fire protection system applications are described in Lewis U.S. Pat. No. 2,310,798, which is based on the use of impinging jets to create a "cloud" of spray, as well as Loepsinger U.S. Pat. No. 2,361,144 and Papavergos U.S. Pat. No. 4,989,675, which are based on establishing a gas-water mixture to create an atomized spray. Further techniques for delivering fine spray for fire suppression purposes include: using an array of nozzles originally designed for fine oil mist atomizing, e.g. in oil burner applications, and using nozzles with an internal fixed scroll, or a whirling device, e.g. as described in PCT Publication No. WO 92/20454.

Within the water spray fire protection field, there has been extensive use of hemispherical or spherical surfaces downstream of the nozzle or sprinkler orifice, to act as a first stage splitter or diverter in conjunction with a second stage deflector which distributes the water spray over the area to be protected. In most of these cases, the splitter is utilized to spread out the stream of fluid flow over a greater area, so that a larger deflector can be used to distribute the fluid over the area to be protected. Such an approach allows a wide range of second stage deflector designs to be implemented for control of the distribution of fluid over the area to be protected. Examples of such use with hemispherical splitter surfaces are given in W. Johnson U.S. Pat. No. 4,465,141 and K. Johnson U.S. Pat. No. 4,596,289. A similar principle is involved in Hanson U.S. Pat. No. 3,051,397, although, in this case, a spherical splitter is used to first fan out the fluid stream against the interior of a cylindrical wall for the purpose of agitating the fluid and entraining air drawn in from the inlet, prior to the resultant fluid mixture being distributed by a downstream deflector, over the area to be protected. However, it should be noted that in this patent, Hanson '397 also indicates that a spherical splitter was used for the sake of simplicity and that a hemispherical splitter would have performed the required function.

There has also been extensive use of hemispherical elements in fire protection nozzles and sprinklers as a mounting location for the fluid deflectors at the junction point of structural support arms extending from the nozzle or sprinkler base. However, in cases such as those illustrated in Martin U.S. Pat. No. 891,278 and Whitaker U.S. Pat. No. 4,585,069, the hemispherical design has also been selected to suitably spread the fluid stream being emitted from the nozzle (sprinkler) orifice over the second stage nozzle (sprinkler) deflector, for distribution over the area to be protected. However, it is well known in the art that, because of the diverting effect that even hemispherical surfaces have on the fluid stream being discharged from the nozzle orifice, their use as a first stage splitter results in a relatively hollow cone or zone of light spray in the region to be protected that is downstream of the nozzle and coaxial with the nozzle orifice. The volume of this zone of light spray may be either increased or decreased by the second stage deflector, depending upon its design. Hanson U.S. Pat. No. 3,051,397 teaches the use of a spherical splitter only for the purpose of simplicity, with acknowledgement that the desired diverting of the fluid stream and the fanning out of the spray to the inside wall of an enclosing cylinder could be performed with a hemispherical splitter. In addition, as illustrated, Hanson '397 required a deflector downstream of the splitter to distribute the fluid mixture over the area to be protected and, the central conical region immediately upstream of the deflector resulted in a zone of light spray in the region to be protected downstream of and coaxial with the device. Furthermore, the spherical splitter is described by Hanson '397 as being selected to have a diameter slightly greater than that of the orifice only to ensure that substantially all of the fluid stream would impinge on the splitter, even if the stream

expanded somewhat between the nozzle orifice and the splitter.

## SUMMARY OF THE INVENTION

This invention concerns a new type of fire protection nozzle, primarily intended for use in Class B fire situations, comprising a diffuser element capable of distributing a relatively high momentum fine spray, with the majority of the water droplets having a diameter of less than 300 microns, as described in "Fire Test Report on the Evaluation of the AquaMist® Fixed Water Mist Deluge System in Ventilated Marine Machinery Spaces" by Jerome S. Pepi (published Jun. 28, 1994). In its preferred embodiment, the diffuser element defines a spherical surface located coaxially with the nozzle orifice and downstream of the orifice, for the purpose of distributing a spray of water mist over the area to be protected, with a relatively filled cone of spray in the region downstream of and coaxial with the nozzle. Also, in its preferred embodiment, the spherical surface of the diffuser element of the invention has an equatorial diameter of at least twice the diameter of the fluid stream being emitted from the nozzle orifice.

Objectives of this invention include to provide an improved fine spray (water mist) fire extinguishing nozzle that is simple, reliable and has a relatively low manufacturing cost. A further objective of this invention is to provide a water mist nozzle that can distribute a relatively filled cone of spray over the area to be protected, with the majority of the water droplets having diameters of less than 300 microns (0.012 inch) at a pressure of about 175 psi. Another objective of this invention is to provide a water mist fire extinguishing nozzle that emits relatively high momentum fine droplets which are capable of projecting distances of 5 meters (16 feet) or more and penetrating the strong updrafts of established hydrocarbon fuel fires as well as being deflected and re-distributed throughout the volume to be protected, even into areas that are somewhat shielded or concealed from the spray discharged directly from the nozzle.

Objectives of this invention also include to provide the above performance characteristics at a relatively low flow rate per nozzle, but not such a low flow rate that requires use of an undesirably small orifice that is excessively susceptible to clogging due to debris in the fluid supply, unless a very fine filter is used to screen the fluid flow to the nozzle orifice.

According to the invention, a fire protection nozzle achieving one or more of these objectives comprises a base, an orifice, defined by the base and having a predetermined diameter, through which fire-retardant fluid can flow, an inlet section having an upstream end and defining a conduit for flow of the fire-retardant fluid along a conduit axis and leading to an upstream end of the orifice, a diffuser element positioned coaxially with and downstream of the orifice, and one or more arms extending from the base and supporting the diffuser element in a position, where, when flow of the fire-retardant fluid from the inlet section through the orifice is established, the fire-retardant fluid emerges from the orifice in a stream which impinges on a diffuser surface defined by the diffuser element to be distributed in a spray pattern. The diffuser surface defined by the diffuser element is generally spherical in shape in a region extending from an upstream end closest to the orifice to at least downstream of an equatorial plane of the diffuser element transverse to the conduit axis.

Preferred embodiments of the invention may include one or more of the following additional features. The diffuser surface of the diffuser element has a diameter of at least two times (preferably two to four times, and more preferably about three times) the predetermined diameter of the orifice. The diameter of the diffuser surface of the diffuser element is between about 0.18 inch and 0.38 inch, and preferably is about 0.28 inch, and more preferably occurs at the equatorial plane. The diameter of the orifice is between about 0.06 inch and 0.12 inch, and preferably is about 0.09 inch. The fire retardant fluid flowing from the orifice has a pressure of 100 psi or above, and preferably about 170 psi or above. The fire protection nozzle further comprises two support arms, and an apex element disposed at a juncture of the arms, generally coaxial with the conduit axis, and the diffuser element is mounted at an end of the apex closest to the orifice, with an area of intersection of the diffuser element and the apex in a plane perpendicular to the conduit axis having a diameter about 65 percent or less of the diameter of the diffuser element at its equatorial plane, whereby a portion of the fire retardant fluid discharging from the orifice remains attached upon the diffuser surface of the diffuser element downstream, past the equatorial plane, thereby, providing a relatively filled cone of fine spray from the nozzle. Preferably, the diffuser element is secured upon the apex by resistance welding.

The nozzle base, arms, apex, diffuser element and orifice (which may or may not be separately fabricated from the base) are manufactured of stainless steel, to provide sufficient resistance to the intense heat which can be associated with direct impingement of the flames from a high pressure hydrocarbon fuel fire as well as, resistance to corrosion which could be caused by salt air or use of sea water as the fire retardant fluid media. The spherical diffuser element is positioned coaxial with the nozzle orifice by two support arms extending from the base, on opposite sides of the orifice and joined together at an apex downstream of the spherical diffuser element so as to minimize the disturbance to the pattern of the mist which is distributed over the area to be protected.

The spherical diffuser element for a fire protection nozzle of the invention thus provides distribution of fire retardant fluid over the area to be protected and, more specifically, provides distribution of a fine spray or mist in a generally conical pattern that is relatively filled with fluid droplets with features as described above. These attributes have been achieved through the discovery that fine droplets become detached from all around the spherical surface of the diffuser element of this invention, including that portion of the spherical surface which is downstream of its equatorial plane, which results in a generally conical spray pattern that is nearly completely filled with fine fluid droplets.

Furthermore, it has been found that at pressures of 100 psi and above and more preferably at pressures of 170 psi and above, the fine fluid droplets which are distributed by the spherical element have the required predetermined projection distance, combined with the relatively high momentum, necessary to penetrate strong upward drafts associated with hydrocarbon fuel fires and the like, due in great part to the streamlined nature of the fluid flow around the spherical surface of the diffuser element of the invention.

To a certain extent, the portions of the nozzle support arms which are located downstream of the spherical diffuser element, in the preferred embodiment of this invention, provide narrow openings in the spray pattern close to the nozzle. However, by utilizing a relatively narrow width along the upstream (inside) edges of the arms, combined with a streamlined shape for the arms in the vicinity of the apex, the disturbance to the spray pattern caused by the arms is minimized and of no substantial consequence, over 0.5 m (1.6 feet) from the nozzle.

Further objectives of the invention include providing a nozzle, e.g., for use as part of a fire extinguishing system, for use in extinguishing Class B fires involving flammable hydrocarbon liquids and gases, for use in extinguishing Class A fires involving ordinary combustible materials such as wood, cloth, paper and plastics, as well as for use in extinguishing Class C fires involving electrical or electronic equipment where consideration of the electrical conductivity of the extinguishing media is of importance.

## BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a front elevation of a fire protection sprinkler nozzle with a spherical diffuser surface of the invention;

FIG. 2 is a side elevation, taken in section, of the fire protection sprinkler nozzle having the spherical diffuser surface of FIG. 1; and

FIGS. 3 and 4 are somewhat diagrammatic, enlarged front and sides view, respectively, both taken in section, showing fluid flowing from the orifice onto the diffuser element surface to be diffused into a generally conical spray pattern that is nearly completely filled with fine fluid droplets.

## DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

Referring to FIG. 1, a fire protection sprinkler nozzle **10** of the invention has a base **14** defining external threads **16** for threaded sealed connection to a fire retardant fluid supply system (not shown).

Referring also to FIG. 2, the base **14** defines an axial passageway **18** therethrough for flow of fire retardant fluid from the inlet **20** (in communication with the fluid supply system) to the outlet **22**, exterior of the base. In a region downstream of the outlet, arms **24**, **26** extend from the base **14** to an apex **28** positioned downstream of and coaxial with the orifice **30**, defined by orifice insert **31** positioned within passageway **18** of base **14**, e.g. much the same as in traditional nozzles typically used for fire protection system service.

A strainer **32** is positioned across the inlet **20** to passageway **18** in manner to protect orifice **30** in orifice insert **31** from clogging, e.g., due to debris in the fluid supply system. Under standby conditions (FIG. 2), an elastomeric plug **34** seals the outlet **22** to passageway **18** and the orifice **30** from airborne debris or insects that might tend to clog the orifice. Wire **36** attaches the plug **34** to the base **14** of the nozzle so that the plug will not be blown away from the nozzle upon discharge of fluid from the nozzle.

In principle, the device so far described operates in much the same manner as many of the nozzles used in fire protection system service today.

Referring again to FIG. 2, in the nozzle **10** of the invention, a spherical diffuser element **40** is positioned coaxially with the centerline, $C_o$, of the orifice **30**, with the diffuser element **40** partially recessed within and centered by axial bore **29** defined in apex **28**, and secured, e.g., by resistance welding, at the upstream end of apex **28** of the support arms **24**, **26**.

In a preferred embodiment of the invention, the nominal diameter, $D_o$, of the orifice **30** is 0.091 inch; the diffuser element **40** has an outer surface **42** in the shape of a sphere, with a nominal diameter, $D_d$, of 0.281 inch at its equatorial plane; the diameter, $D_s$, at the intersection of the spherical outer surface **42** of the diffuser element **40**, and apex **28**, partially recessed within and centered by hole **29**, with a



horizontal plane, $P_i$, extending through the upper edge **44** of the apex **28**, is nominally 0.18 inch; and the nominal diameter, $D_p$, of the perforations **46** in the strainer **32** are 0.060 inch. The upstream (inside) edges **48**, **50** of the arms **24**, **26** in the vicinity of the apex **28** are nominally 0.03 inch thick, gradually increasing to a nominal thickness of 0.10 inch at their downstream (outside) edges **49**, **51**.

Referring now to FIGS. 3 and 4, upon actuation, fire retardant fluid is caused to flow from the fire retardant fluid supply system (not shown), through perforations **46** in strainer **32**, into passageway **18** via inlet **20** and through orifice **30**. The pressure of fluid flow from the orifice dislodges the plug **34** (secured by wire **36**) from the outlet **22**, allowing the fluid **54** to impinge upon the spherical diffuser surface **42** of the spherical diffuser element **40**. As represented in the drawings, fine droplets **56** become detached from all around the spherical surface **42** of the diffuser, element **40**, including that portion **43** of the spherical surface **42** which is downstream of its equatorial plane, $P_e$, which results in a generally conical spray pattern **58** that is nearly completely filled with fine fluid droplets.

Other embodiments of the invention are within the scope of the following claims. For example, a spherical diffuser element of the invention may be part of a nozzle with an orifice that discharges a coherent fluid stream, to minimize splashing upon impingement of the stream against the spherical diffuser surface, as well as to maintain a spray pattern with an envelope that varies relatively little in outside dimension over the pressure range of from 100 to 300 psi.

A hand held nozzle of the invention for spraying mist onto a fire by trained fire service personnel may define an orifice **30** substantially larger in diameter, e.g. 1.00 inch or more.

Also, the diffuser surface of a diffuser element in a nozzle of the invention may have a diameter four or more times the diameter of the orifice, if diameter $D_p$ (FIG. 1) is made sufficiently small and some lightening of the concentration of the droplets can be tolerated in the zone coaxial with and downstream of the nozzle.

The apex **28** at the juncture of frame arms **24**, **26** may have a shape defining a spherical diffuser surface, thus eliminating the need for a separate diffuser element and further eliminating the operation of securing a separate diffuser element to the apex.

The diffuser element **40** may define another, smoothly changing, but more complicated shape, e.g., a spheroid, to accomplish objectives of the invention in manner similar to that achieved by the preferred embodiment of the invention described above, but distributing the spray in a different, preferential pattern over the area to be protected.

The spherical or other diffuser element of the invention may be located downstream of the one or more support arms, provided that the arms are sufficiently streamlined to minimize disturbance to the fluid stream impinging on the diffuser element surface. The spherical diffuser element may also be connected, e.g., to a cylindrical stem which, in turn, is attached to the apex of the nozzle support arms, or to the nozzle base, to position the diffuser element in a preferred position.

The spherical diffuser element of the invention may be utilized as part of an automatically operating nozzle, with a temperature sensitive release element, means for adjusting the axle position of the diffuser element diffuser surface, means for securing the temperature sensitive release element, and/or an orifice seal in a normal or standby condition.

What is claimed is:

1. A fire protection nozzle comprising

a base defining an orifice having a diameter through which fire-retardant fluid can flow,

an inlet section having an upstream end and defining a conduit for flow of fire-retardant fluid along a conduit axis and leading to an upstream end of said orifice,

a diffuser element positioned coaxially with and downstream of said orifice, said diffuser element defining a diffuser surface that is generally spherical in shape in a region extending from an upstream end closest to said orifice to at least downstream of an equatorial plane of said diffuser element transverse to said conduit axis, said diffuser surface having a diameter that is at least two times the diameter of said orifice, and

one or more arms extending from said base for fixedly supporting said diffuser element in position,

wherein when a flow of fire-retardant fluid from said inlet section through said orifice is established, fire-retardant fluid emerges from said orifice in a stream which impinges on said diffuser surface and is thereby distributed in a spray pattern over an area to be protected.

2. The fire protection nozzle of claim 1 wherein the diameter of said diffuser surface is between two times and four times the diameter of said orifice.

3. The fire protection nozzle of claim 1 wherein said diameter of said diffuser surface is approximately three times the diameter of said orifice.

4. The fire protection nozzle of claim 1 wherein the diameter of said diffuser surface is between about 0.18 inch and 0.38 inch.

5. The fire protection nozzle of claim 1 wherein the diameter of said diffuser surface is about 0.28 inch.

6. The fire protection nozzle of claim 1, 2, 3, 4, or 5 wherein the diameter of said diffuser surface occurs at the equatorial plane of said diffuser element.

7. The fire protection nozzle of claim 1 wherein the diameter of said orifice is between about 0.06 inch and 0.12 inch.

8. The fire protection nozzle of claim 1 wherein the diameter of said orifice is about 0.09 inch.

9. The fire protection nozzle of claim 1 wherein, when fire retardant fluid flows from said orifice at a pressure of 100 psi or more, as measured at the upstream end of said inlet section, fire-retardant fluid emerges from said orifice in a stream which impinges on said diffuser surface and is thereby distributed in a substantially filled cone of spray pattern over an area to be protected.

10. The fire protection nozzle of claim 1 wherein, when fire-retardant fluid flows from said orifice at a pressure of 170 psi or more, as measured at the upstream end of said inlet section, fire-retardant fluid emerges from said orifice in a stream which impinges on said diffuser surface and is thereby distributed in a substantially filled cone of spray pattern over an area to be protected.

11. A fire protection nozzle comprising

a base defining an orifice having a diameter through which fire-retardant fluid can flow,

an inlet section having an upstream end and defining a conduit for flow of fire-retardant fluid along a conduit axis and leading to an upstream end of said orifice,

a diffuser element positioned coaxially with and downstream of said orifice, said diffuser element defining a diffuser surface that is generally spherical in shape in a region extending from an upstream end closest to said orifice to at least downstream of an equatorial plane of said diffuser element transverse to said conduit axis, said diffuser surface having a characteristic diameter in the equatorial plane,

two arms extending from said base for fixedly supporting said diffuser element in position, and

an apex element disposed at a juncture of said arms, generally coaxial with said conduit axis, said diffuser element being fixedly mounted at an end of said apex closest to said orifice, with an area of intersection of said diffuser element and said apex, in a plane perpendicular to said conduit axis, having a diameter that is about 65 percent or less of the diameter of said diffuser surface in the equatorial plane,

wherein when fire-retardant fluid flows through said orifice, fire-retardant fluid emerges from said orifice in a stream which impinges on said diffuser surface, whereby a portion of the fire retardant fluid impinging on said diffuser surface remains on said diffuser surface downstream, past said equatorial plane.

12. The fire protection nozzle of claim 11 wherein said diffuser element is fixedly secured to said apex by resistance welding.

13. The fire protection nozzle of claim 11 wherein said diffuser surface has a diameter that is at least two times the diameter of said orifice.

* * * * *

US005392993A

# United States Patent [19]

Fischer

[11] Patent Number: 5,392,993

[45] Date of Patent: Feb. 28, 1995

[54] FIRE PROTECTION NOZZLE

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[73] Assignee: Grinnell Corporation,, Cranston, R.I.

[21] Appl. No.: 184,871

[22] Filed: Jan. 21, 1994

[51] Int. Cl.$^6$ ..... B05B 1/26

[52] U.S. Cl. ..... 239/522; 239/498; 239/504; 239/524; 239/590; 169/38

[58] Field of Search ..... 169/37, 38, 39, 40, 169/41, 42, 90; 239/524, 498, 504, 601, 589, 590, 518, 522

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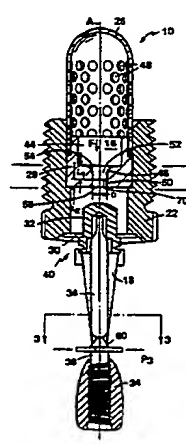
*Primary Examiner*—Andres Kashnikow
*Assistant Examiner*—Christopher G. Trainor
*Attorney, Agent, or Firm*—Fish & Richardson

[57] ABSTRACT

A fire protection nozzle of this invention has a base defining an orifice and an inlet section defining a conduit for flow of fire-retardant fluid, leading to an upstream end of the orifice. A diffuser is supported by arms extending from the base in a position downstream of the orifice where fire-retardant fluid flowing from the inlet section emerges from the orifice in a coherent stream which impinges on the diffuser to be deflected in a spray pattern. The inlet section, in the direction of the fire-retardant fluid flow, has a cross-sectional shape of an inwardly convex curvilinear arc with a length equal to or greater than the diameter of the orifice. In a preferred embodiment, the diffuser defines two or more slots, each having a cross-sectional open area equal to at least eight percent of the total cross-sectional area of the diffuser measured in a plane transverse to the direction of fire-retardant fluid flow from the orifice.

19 Claims, 2 Drawing Sheets



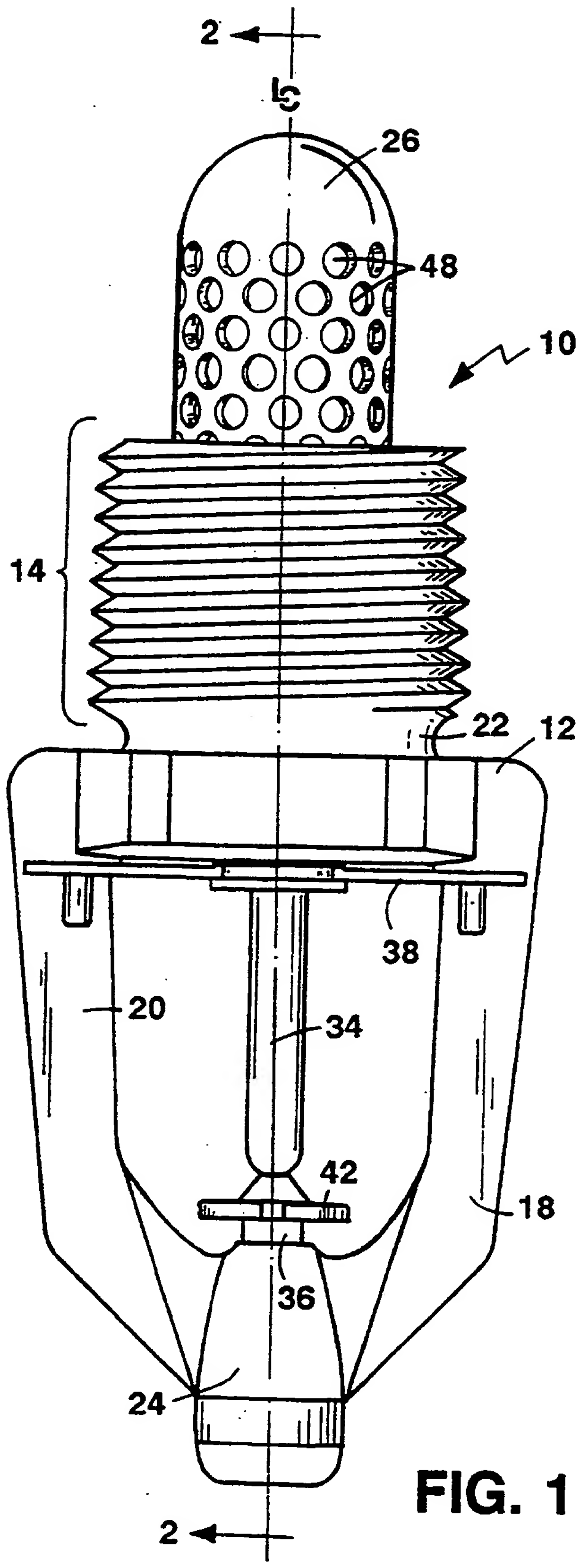
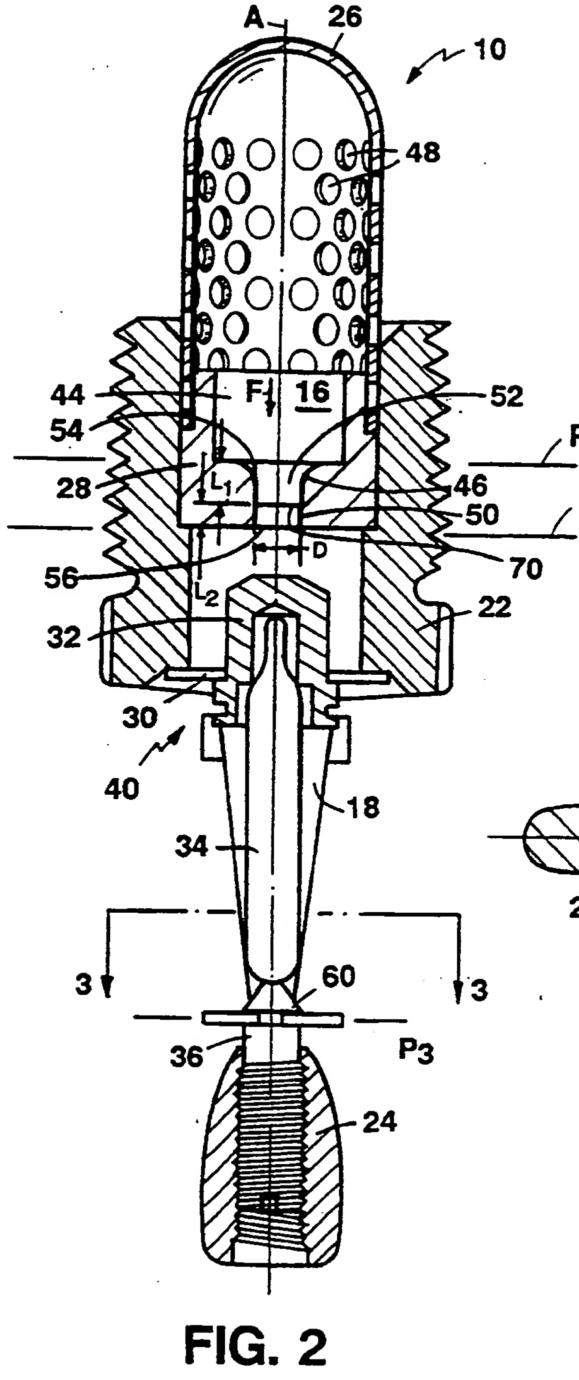



FIG. 1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P3
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FIG. 2

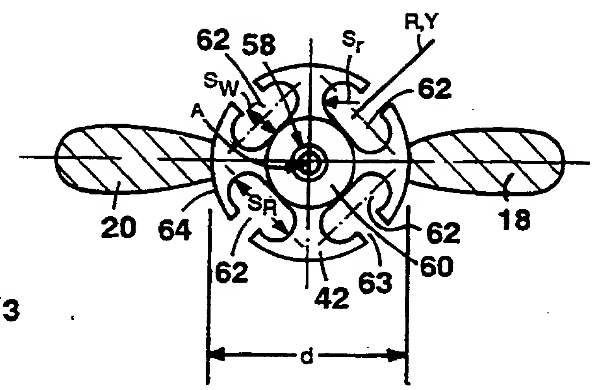
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FIG. 3

# FIRE PROTECTION NOZZLE

## FIELD OF THE INVENTION

This invention relates to manually or automatically operated nozzles for use in discharging fire-retardant liquids.

## BACKGROUND OF THE INVENTION

Fire protection nozzles are used to discharge water, with or without additives, in a relatively fine spray, which is generally referred to in the industry as mist. Nozzles with an inwardly curvilinear inlet section and, in particular, nozzles with an inwardly convex section for which normals to the tangent lines at neighboring points on the curve tend to diverge, are utilized for the purpose of discharging a fire-retardant liquid.

Various types of nozzles discharging a fine water spray have long been used in fire protection systems. Although often not described as such at the time, perforated diffuser sprinklers such as described in Parmalee U.S. Pat. No. 6,257 discharged water in a fine spray by nature of the diffuser holes being in the order of 0.06 inch in diameter. Other examples of fine spray nozzle designs intended for use in fire protection system applications are described in Lewis U.S. Pat. No. 2,310,798, which is based on the use of impinging jets to create a "cloud" of spray, as well as Loepsinger U.S. Pat. No. 2,361,144 and Papavergos U.S. Pat. No. 4,989,675, which are based on establishing a gas-water mixture to create an atomized spray. Further techniques for delivering fine spray for fire suppression purposes include: using an array of nozzles originally designed for fine oil mist atomizing, e.g. in oil burner applications, and using nozzles with an internal fixed scroll, or a whirling device, e.g. as described in PCT Publication No. WO 92/20454.

The mechanism(s) by which fine spray (water mist) acts to control, suppress or extinguish a fire can be a complex combination of two or more of the following factors, depending on the operating concept of the individual nozzle, the size of the orifice(s), the operating pressure and flow rate:

1. Heat extraction from the fire as water is converted into vapor

The amount of evaporation and hence heat withdrawn from the fire (i.e., cooling of the fuel) is a function of surface area of water droplets applied, for a given volume. Reducing droplet size increases surface area and increases the cooling effect of a given volumetric flow rate of water.

2. Reduced oxygen levels as the vapor displaces oxygen near the seat of the fire

When water converts to vapor, it expands by a factor of about 1650 times, displacing and diluting oxygen, thereby blocking the access of oxygen to the fuel. Arsonist fires in enclosures are, therefore, the easiest for water mist systems to extinguish because of the virtually instantaneous vaporization which can occur due to the relatively high level of heat present at nozzle operation, even with fast response release elements.

3. Deluging of the protected area

Small water droplets are extremely light, and tend to remain suspended with the slightest air currents. This results in a "mist" that tends to distribute itself throughout an enclosure, outside of the direct spray range of an individual nozzle. Fine water droplets are, therefore, more likely to be drawn into the seat of the fire, further enhancing the effectiveness of the system by chemically inhibiting the combustion radicals. This three-dimensional effect of the expanding mist also acts to cool the gases and other fuels in the area, blocking the transfer of radiant heat to adjacent combustibles, as well as, pre-wetting them.

4. Direct impingement wetting and cooling of combustibles

In addition to the pre-wetting and cooling of the flames by vaporizing water droplets, fire extinguishment by direct contact of the water droplets with the burning fuel to prevent further generation of the combustible vapors is one of the modes of fire extinguishment normally associated with traditional sprinklers having orifice diameters most often of about 0.44 inch or larger. However, with a fast response release mechanism, high momentum mist can be effective in this mode during the early development stage of exposed fires.

Generally speaking, the sizes of the orifices used in water mist nozzles are in the order of 0.06 inch in diameter or less, with the orifice diameter becoming smaller as the flowing pressure is increased, in order to restrict the flow to a reasonable value. For example, nozzle assemblies made up of fine oil mist-type sprayers generally have orifice diameters in the order of 0.02 inch or smaller and are operated at pressures of about 1,000 psig or higher. As compared to traditional sprinklers with orifice diameters most often of about 0.44 inch or larger, water mist nozzles with orifice diameters of about 0.06 inch or smaller require the use of fine inlet mesh strainers to prevent clogging due to debris in the water supply, while nozzles with orifice diameters of 0.02 inch or smaller are considered to be excessively susceptible to clogging by either debris or mineral deposits in the water supply or corrosive atmospheres like that associated with a marine environment. As such, very fine mesh inlet strainers are needed to protect the orifices, the nozzle bodies need to be made of costly corrosion resistant materials and, in addition, the use of deionized water as well as protective exterior caps (which would blow off following nozzle operation), should be considered. Lastly, operation of water pumps at 1,000 psi or higher, especially in marine service, raises questions as to the degree of maintenance required in order to ensure the level of reliability necessary for helping to assure safety of life in a fire situation.

Dual media water mist systems such as the gas-water mixture system described in Papavergos U.S. Pat. No. 4,989,675 tend to have a larger and more acceptable water discharge orifice diameter (in the order of 0.12 inch) and operate at pressures in the order of 45 psig to 75 psig. However, dual media systems have the extra costs and complexity associated with installing two sets of piping to each nozzle, they must be operated as a deluge system (e.g., water is flowed from a number of nozzles at once, to cover a relatively wide area), and a separate source of relatively high flow rate compressed gas must be maintained. The gas source is normally provided by using cylinders of compressed nitrogen at pressures of greater than 2,000 psig, and, because of the fixed volume of gas supply, it is also necessary to make provisions for discharging multiple shots of the water mist, with each shot lasting a few minutes, in the event that the fire re-ignites after the first shot of the mist. This makes the equipment more complex and costly. Lastly, with the dual media system, care must be taken to prevent over-pressurization of a compartment, other-

wise structural damage to the compartment might result upon release of the gas-water mixture.

There is also a variety of background information concerning nozzles, with various types of inwardly convex curvilinear inlet sections for which normals (i.e., perpendiculars) to tangents at neighboring points on the curve tend to diverge, that have been used for applications such as discharging: fire-retardant fluids, water for irrigation, rocket fuels, and chemicals used in industrial processes. Prior art illustrating nozzles with various types of inwardly convex curvilinear inlet sections, which are used for discharging fire-retardant liquids, include the following: Gilmore U.S. Pat. No. 488,003; Reed U.S. Pat. No. 781,159; Berna U.S. Pat. No. 1,315,079; Livingston U.S. Pat. No. 3,872,928; Livingston U.S. Pat. No. 3,884,305; Klein U.S. Pat. No. 4,800,961; Polan U.S. Pat. No. 4,991,656 and Simons U.S. Pat. No. 5,195,592.

Prior art nozzles for irrigation applications are described in Varner U.S. Pat. No. 4,228,956 and Drechsel U.S. Pat. No. 4,842,199. A prior art nozzle with inwardly convex inlet sections for use in rocket fuel applications is described in Ledwith U.S. Pat. No. 3,171,248, while prior art nozzles with inwardly convex inlet sections for use in chemical process applications are described in Devillard U.S. Pat. No. 3,130,920 and East U.S. Pat. No. 3,550,864.

## SUMMARY OF THE INVENTION

It is an objective of this invention to provide an improved fine spray (water mist) fire extinguishing nozzle that is simple, reliable and low cost for manufacture.

It is a further objective of this invention to provide a water mist nozzle that can be individually automatically released (operated), a nozzle that is effective for extinguishing certain classes of fires at a flowing pressure as low as about 87 psig. It is also an objective of this invention to provide a nozzle which discharges a fine spray (water mist) with an orifice diameter equal to or larger than 0.10 inch, so that the strainer used to protect the orifice from clogging due to debris in the water supply will not require unusually small and costly perforations, and so that the orifice will not be subject to clogging due to mineral deposits such as calcium in the water supply.

Objectives of this invention have been discovered to be achievable with an individually automatically operating nozzle.

In particular, according to the invention, a fire protection nozzle comprises a base, an orifice, defined by the base and having a predetermined diameter, through which fire-retardant fluid can flow, an inlet section defining a conduit for flow of fire-retardant fluid and leading to an upstream end of the orifice, a diffuser element positioned downstream of the orifice, and one or more arms extending from the base and supporting the diffuser element in a position, where, when flow of fire-retardant fluid from the inlet section through the orifice is established, the fire-retardant fluid emerges from the orifice in a coherent stream which impinges on the diffuser element to be deflected in a spray pattern, the inlet section, in the direction of fire-retardant fluid flow, having a cross-sectional shape of an inwardly convex curvilinear arc, and the inlet section having a length equal to or greater than the diameter of the orifice.

Preferably, the inwardly convex curvilinear arc of the cross-sectional shape of the inlet section has the form of a circular arc, with the center of the circular arc located proximate to the plane of the upstream end of the orifice, and the radius of the circular arc is between one and three times the diameter of the orifice, and, more preferably, the radius of the circular arc is approximately 1.5 times the diameter of the orifice.

In an alternative embodiment, the inwardly convex curvilinear arc of the cross-sectional shape of the inlet section has the form of an ellipse with the center of the ellipse located proximate to the plane of the upstream end of the orifice. Preferably, the ellipse has a major axis with a length between 1.5 and 4.0 times, and preferably nominally 2.0 times, the diameter of the orifice, and the ellipse has a minor axis with a length between 1.0 and 3.0 times, and preferably nominally 1.3 times, the diameter of the orifice.

In another alternative embodiment, the inwardly convex curvilinear arc of the cross-sectional shape of the inlet section has the form of a smooth blend of two or more circular arcs of different radii, the two or more circular arcs in combination approximating the form of an ellipse.

Preferred embodiments of this aspect of the invention may include one or more of the following additional features. The cross-sectional area of the conduit, measured in a first plane at the upstream end of the inlet section and transverse to the direction of fire-retardant fluid flow, is at least seven times the cross-sectional area of the orifice measured in a second plane transverse to the direction of fire-retardant fluid flow. The diameter of the orifice is between about 0.08 inch and 0.20 inch, and preferably nominally 0.11 inch. The orifice has an exit end contour essentially in the form of a square corner.

According to another aspect of the invention, a fire protection nozzle comprises a base, an orifice defined by the base through which fire-retardant fluid can flow, an inlet section defining a conduit for flow of fire-retardant fluid leading to the orifice, a diffuser element positioned downstream from the orifice, and one or more arms extending from the base for supporting the diffuser element, in a position where, when flow of fire-retardant fluid through the orifice is established, the fire-retardant fluid emerges from the orifice in a coherent stream and impinges on the diffuser element to be deflected in a spray pattern, the diffuser element defining two or more slots, the diffuser element having a total cross-sectional area measured in a plane transverse to the direction of fire-retardant fluid flow from the orifice, and each slot having a cross-sectional open area, measured in the plane, equal to at least eight percent of the total cross-sectional area of the diffuser element.

Preferred embodiments of this aspect of the invention may include one or more of the following additional features. The diffuser element and the orifice are coaxial arranged, and each slot has a long axis disposed transverse to a radial line drawn from the axis of the diffuser element. The diffuser element and the orifice are coaxial arranged, and the diffuser element defines four slots, each slot having a cross-sectional open area measured in the plane approximately equal to ten percent of the total area of the diffuser element in the plane, and each slot has a long axis disposed transverse to a radial line drawn from the axis of the diffuser element. The diffuser element and orifice are coaxially arranged, each slot has a long axis disposed substantially transverse to a radial line drawn from the axis of the diffuser element, and an open channel is defined between the associated slot and

an outer edge of the diffuser element, the channel being narrower than the associated slot. Preferably, the channel has an axis generally aligned with a radial line drawn from the axis of the diffuser element and/or substantially transverse to the long axis of the associated slot.

These and other features and advantages of the invention will be apparent from the following description of a presently preferred embodiment, and from the claims.

## BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a face view of a fine spray fire protection nozzle of the invention;

FIG. 2 is a side sectional view of the fine spray fire protection nozzle of the invention, taken at the line 2—2 of FIG. 1;

FIG. 3 is a top sectional view of the diffuser element of a fine spray fire protection nozzle of the invention, taken at the line 3—3 of FIG. 2.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, an individually automatically operating nozzle 10 includes a frame 12 with external threads 14 for sealingly connecting it to a fire retardant fluid supply system (not shown). Referring also to FIG. 2, an axial passageway 16 defined through the frame 12 communicates from the fluid supply to the exterior of the frame. Arms 18, 20 extend from the main body 22 of the frame to an apex 24 positioned away from and coaxial with the passageway in the frame 12, much the same as in traditional sprinkler heads typically used for automatic fire protection system service.

A strainer 26 is positioned across the passageway 16 in manner to protect the orifice insert 28 from potential clogging due to debris in the fluid supply system. A spring seal 30 and button 32 sealingly close the passageway through the frame 12, and the opening is held closed by a frangible bulb-type heat-responsive release element 34 which bears between the button 32 and deflector-loading screw 36, which is threaded into frame 12 at the apex 24 of arms 18, 20 extending from the frame. An ejection spring 38 imposes a lateral force on the button-and-spring-seal sub-assembly 40 such that when the release element 34 bursts at a predetermined temperature due to exposure to the abnormally high temperatures caused by a fire, the button 32 and spring seal 30 are thrown to the side from their normal or standby sealing position, thereby to allow fluid to discharge through the passageway 16 and impinge upon the down-stream diffuser element 42, secured by the deflector-loading screw 36, to form the desired water spray pattern. In principle, the device as so far described operates in much the same way as the traditional automatic sprinklers used today in fire protection system service.

Referring again to FIG. 2, in an individually automatically operating nozzle 10 of the invention, the nozzle entrance region 44 upstream of the orifice inlet section 46 is pressurized with fire retardant fluid which is supplied by the connection to the fire protection system piping and flows through the perforations 48 in the strainer 26. The exact shape or cross-sectional area of entrance region 44 and perforations 48 are not critical to the fine spray forming qualities of the nozzle 10 of this invention. However, it is preferable, for the purpose of realizing the objectives of this invention, that the entrance region have a cross-sectional area, measured in a plane, $P_1$, transverse to the axis, A, of the direction of fire retardant fluid flow through the orifice 50, in the order of eight or more times the cross-sectional area of the orifice 50, measured in a plane, $P_2$, also transverse to the axis, A, of the direction of fire retardant fluid flow through the orifice 50. It is also preferable for the purpose of realizing the objectives of this invention that the perforations 48, taken together, have a total cross-sectional open area in the order of 20 or more times the area of the orifice 50, to avoid introduction of significant alteration to the flow characteristics through the passageway 16 formed by the orifice inlet section 46 and orifice 50, over the pressure (flow) range of interest. The size of the individual strainer perforations 48 must, however, be smaller than that of the orifice 50, so that any debris which is small enough to pass through the perforations is also sufficiently small to pass through the orifice inlet and thus not clog the orifice. The total cross-sectional area for the strainer needs to be greater than that for the orifice inlet, in order to allow for the partial blockage effect created by any debris collecting around the outside of the strainer.

Heretofore, the discharge streams and resulting spray patterns of nozzles (sprinklers) with orifice diameters less than 0.20 inch and passageway configurations like those described in the prior art have been known to be stable only over a relatively limited range of pressures, up to pressures in the order of 80 psig. At higher pressures, the flow stream exiting the orifice becomes unstable for at least two reasons which have been found to be of particular importance: the first being due to a change in direction of the fluid entering the orifice area, and the second being due to discontinuities in the contour of the exit or downstream end of the orifice.

However, the instabilities described above are unacceptable in the case of a nozzle having an orifice diameter of about 0.11 inch, as necessary for discharge of a suitable fine spray (water mist), since it has been found that a minimum pressure of about 87 psi is needed to establish the momentum required for penetration of the fine spray through the updrafts created by a fire. These instabilities would also be unacceptable for a fine spray device expected to operate in much the same manner as traditional automatic sprinklers, since the latter are typically rated for use at a maximum service pressure of 175 psig.

With respect to the first described cause of instability, what would appear to be smooth changes in the contour of the inlet section, e.g. as described in Polan U.S. Pat. No. 4,976,320 and Simons U.S. Pat. No. 5,195,592, as well as in Klein U.S. Pat. No. 4,800,961, can actually cause detachment of the flow stream from the wall of the waterway at pressures greater than about 80 psig and with orifice diameters less than 0.20 inch. This detachment from the wall, especially in an area immediately upstream of the orifice, causes a collapse in the diameter of the flow stream, and, slightly further on, an expansion of the flow stream into a conical condition. This expansion from a cylindrical shape at pressures higher than that which produces detachment significantly alters the resultant water spray pattern of nozzles utilized with diffusers. Since the expanded flow stream impinges the diffuser over a larger area, and most often in the area of the diffuser slots which are needed to produce an acceptable distribution of the water, the spray pattern collapses to a size unacceptably smaller than the size of the spray pattern in the stable pressure range.

In the present invention, it has been found that the fluid stream exiting from an orifice 50 having a diameter, D (measured in the region of plane $P_2$), of about 0.11 inch can be made extremely stable, without any significant alteration of the water spray pattern, up to pressures of more than 300 psi by utilizing an inwardly convex, curvilinear shape for the surface 54 of the inlet region 52 of section 46 into the orifice 50 for which normals to the tangent lines at neighboring points on the curve surface 54 tend to diverge, in combination with particular dimensions in relationship to the diameter, D, of the orifice 50.

In the ideal case, it has been found that in order to provide an extremely stable (i.e., essentially non-expanding) flow stream, for the fluid exiting the nozzle orifice 50, the orifice inlet region 52 must provide a surface 54 which smoothly and gradually blends the transition from the entrance to the orifice 50, such that discontinuities in the fluid flow do not occur in the passageway from the start of the inlet region 54 (in the region of plane $P_1$) to the end of the orifice 50 (in the region of plane $P_2$). A significant improvement in the flow stable pressure to a minimum of about 130 psig is achieved by making the cross sectional shape of the curvilinear inlet region (in the direction of flow of fire retardant fluid, arrow F) a circular arc having a radius equal to at least 1.0 times the diameter, D, of the orifice 50. However, a still further increase in the flow stable pressure to more than 300 psig has been obtained by making the cross sectional shape of the surface 54 of curvilinear section in the region 46 an elliptical arc, wherein the length of the major axis of the ellipse is approximately equal to twice the diameter, D, of the orifice 50 and the length of the minor axis of the ellipse is approximately equal to 1.3 times the orifice diameter. It has also been found that combinations of two or more radii can be used to approximate the shape of an ellipse, as long as all radius transition points are smoothly blended.

In addition to the shape of the surface 54 defining the orifice inlet region 52 being of critical importance in the stability of the fluid stream being discharged from the orifice 50, when used in conjunction with a downstream diffuser 42, the contour of the exit or downstream end 56 of the orifice 50 is also extremely important. If the corner of the exit 56 of the nozzle orifice 50 of this invention could be fabricated in general production with a chamfer or radius which was perfectly concentric with the orifice 50 and perfectly symmetrical about any radial axis, then the flow stream would run straight and true to the center axis, A, of the diffuser 42. However, from a practical standpoint, this is not achievable at an acceptable cost because the orifice inlet section 46 and the contour around the exit end 56 of the orifice 50 must be machined from opposite ends; and, the consequences of even slight variations in the concentricity or symmetry of the contour around the exit end of an orifice of the size in the nozzle of this invention can cause the flow stream to diverge from the longitudinal axis, A, of the orifice 50 and produce an unacceptable dislocation of the spray pattern. However, it has been found that if the corner of the exit end 56 of the orifice 50 is made an essentially sharp corner, in addition to removing any burrs left from the orifice machining operation, the flow stream emanating from the orifice will run straight and true to the center axis, A, of the diffuser 42.

In the preferred embodiment of this aspect of the invention, the nominal diameter of the orifice 50 is 0.106 inch, and the cross sectional shape of the surface 54 in the region 52 of the orifice inlet section 46 is in the form of a quadrant of an elliptical arc, with the major axis of the ellipse being nominally 0.212 inch long and the minor axis of the ellipse being nominally 0.142 inch long. Further, the tangent to the elliptical surface 54 at the minor axis is coincident with the upstream edge 70 of the orifice 50 or, in other words, the length of one-half the major axis of the ellipse is equal to the length, $L_1$, of the orifice inlet section. The length, $L_2$, of the orifice is nominally 0.064 inch long, and the corner edge around the exit end 56 of the orifice 50 is essentially square.

Referring now also to FIG. 3, another aspect of this invention involves the unique and unusually shaped diffuser element 42 of the deflector-loading screw 36. The diffuser element 42, which establishes the water spray pattern, is located downstream of the orifice 50 and the size of the diffuser element is relatively small, in proportion to the diameter of the flow stream. The diffuser element of this invention is unusual in that the deflector-loading screw 36 is of one-piece construction; however, it functions similarly to diffusers of traditional automatic sprinklers of larger orifice diameters by causing the flow stream emanating from the orifice to be broken up into a pattern of spray; with the size of the pattern, drop size and distribution of droplets within the over-all pattern being variable in accordance with the geometry of the diffuser.

In the embodiment of FIG. 1, the seat 58 for the release element 34 and the conical surface 60 have an effect on the water spray pattern distributed by the diffuser 42, and, as such, are considered to be part of the diffuser when referring to it herein.

Of a unique nature is the configuration of the four diffuser slots 62 which are elongated in a direction substantially perpendicular or transverse to a radial line, R, drawn from the center axis, A, of the diffuser. The transversely orientated slots 62 provide sufficient flow area through the diffuser 42 such that four, web-like spray components, each containing a relatively large portion of the total discharge volume, are created. These web-like spray components are composed of a wide range of drop sizes specifically placed within the web, from fine spray (mist) size to the larger droplets associated with traditional sprinklers having an orifice diameter of 0.44 inch or larger. The larger droplets are incorporated to help penetrate updrafts created by an exposed fire when the nozzle 10 is located at a relatively high ceiling-to-floor distance, e.g. 16 feet, as well as to help draw the finer spray along toward the fire and to the floor as well. In addition, when nozzles 10 of the invention are used at a more typical ceiling-to-floor distance of about 8 feet, the momentum of the web-like spray components (in addition to their entrained air flow) impinging against the floor as well as furniture causes the spray to be carried outward such that portions of the spray become re-distributed into more remote or concealed areas that would otherwise not be in the direct line of spray from the nozzle. In order to achieve these desired attributes, the cross-sectional open area of each of the four transverse orientated slots (measured in a plane, $P_3$, transverse to the axis, A, of the diffuser element 42) must be at least 8 percent of the total cross-sectional area of the diffuser (including the release element seat 58 and conical surface feature 60)

projected into plane, $P_3$. FIG. 3 also illustrates a channel-like connection 63 between each slot 62 and the outside edge 64 of the diffuser element 42, each channel being narrower than the width of the slot and being disposed to produce a predetermined desired spray pattern.

In preferred embodiments of this aspect of the invention, the outside diameter, d, of the diffuser is nominally 0.350 inch. Each slot 62 has an over-all length, $S_1$, in the transverse direction of nominally 0.150 inch and an over-all width, $S_w$, of nominally 0.072 inch. The end of each slot is a semi-circle having a radius, $S_r$, of nominally 0.036 inch. As a result, each slot 62 has a nominal area of 10 percent of the total area of the diffuser, projected into a plane, $P_3$. The width of each channel 63 is nominally 0.056 inch.

Other embodiments of the invention are within the scope of the following claims. For example, the cross sectional shape of surface 54 in the direction of flow (arrow F) of the orifice inlet section 46 could be in the form of a curvilinear arc which simply approximates the circular and elliptical arcs described herein.

Also, the contoured surface of the inlet section 46 connecting through the body 22 the fluid supply source could be machined directly in the frame 12.

In addition, the diffuser slots 62 oriented along a long axis, X, disposed essentially transverse to a radial line, R, drawn from the center axis, A, of the diffuser 42, could have a kidney or other generally elongated shape that permits providing the desired minimum area for the slot 62, as a percentage of the total area of the diffuser 42, but adjusts the spread of the web-like spray component generated by the arrangement of slots, as described above. The diffuser 42 may have a shape other than round, and the transverse slots 62 may be joined by a radially outwardly extending channel 63 extending to the outside edge 64 of the diffuser. The position of an axis, Y, of the channel may be varied as desired to obtain different predetermined spray patterns, e.g. the axis, Y, may be disposed coaxially along radial line, R, and substantially transverse to slot long axis, X, as shown in FIG. 3; or the axis Y may be re-positioned to assume a different relationship relative to radial line, R, and/or to slot long axis, X.

These alterations among others would be obvious to those skilled in the art.

What is claimed is:

1. In a fire protection nozzle of the type comprising a base, an orifice, defined by said base and having a predetermined diameter, through which fire-retardant fluid can flow, an inlet section having an upstream end and defining a conduit for flow of the fire-retardant fluid along a conduit axis and leading to an upstream end of said orifice, a diffuser element positioned downstream of said orifice, and one or more arms extending from said base and supporting said diffuser element in a position, where, when flow of the fire-retardant fluid from said inlet section through said orifice is established, the fire-retardant fluid emerges from said orifice in a stream which impinges on said diffuser element to be deflected in a spray pattern,

the improvement wherein

said inlet section, in the direction of the fire-retardant fluid flow, has a conduit surface defining a cross-sectional shape of an inwardly convex curvilinear arc, said inlet section has a length equal to or greater than the diameter of said orifice, and said conduit surface, at said upstream end of said inlet section, lies substantially tangent to a plane perpendicular to said conduit axis.

2. The fire protection nozzle of claim 1, wherein the inwardly convex curvilinear arc of the cross-sectional shape of said inlet section has the form of a circular arc, with the center of said circular arc located proximate to a plane of said upstream end of said orifice.

3. The fire protection nozzle of claim 2, wherein the radius of said circular arc is between one and three times the diameter of said orifice.

4. The fire protection nozzle of claim 3, wherein the radius of said circular arc is approximately 1.5 times the diameter of said orifice.

5. The fire protection nozzle of claim 1, wherein the inwardly convex curvilinear arc of the cross-sectional shape of said inlet section has the form of an ellipse and the center of the ellipse is located proximate to a plane of said upstream end of said orifice.

6. The fire protection nozzle of claim 5, wherein said ellipse has a major axis with a length between 1.5 and 4.0 times the diameter of said orifice, and said ellipse has a minor axis with a length between 1.0 and 3.0 times the diameter of said orifice.

7. The fire protection nozzle claim 6, wherein the length of the major axis of said ellipse is nominally 2.0 times the diameter of said orifice and the length of the minor axis of the ellipse is nominally 1.3 times the diameter of said orifice.

8. The fire protection nozzle of claim 1, wherein the inwardly convex curvilinear arc of the cross-sectional shape of said inlet section has the form of a smooth blend of two or more circular arcs of different radii, the two or more circular arcs in combination approximating the form of an ellipse.

9. The fire protection nozzle of claim 1, wherein the cross-sectional area of said conduit, measured in a first plane at an upstream end of said inlet section and transverse to the direction of the fire-retardant fluid flow, is at least five times the cross-sectional area of said orifice measured in a second plant transverse to the direction of the fire-retardant fluid flow.

10. The fire protection nozzle of claim 1, wherein the diameter of said orifice is between about 0.08 inch and 0.20 inch.

11. The fire protection nozzle of claim 10, wherein the diameter of said orifice is nominally 0.11 inch.

12. The fire protection nozzle of claim 1, wherein said orifice has an exit end with a corner having a cross-sectional contour essentially in the form of a square corner.

13. In a fire protection nozzle of the type comprising a base, an orifice defined by said base through which fire-retardant fluid can flow, an inlet section defining a conduit for flow of the fire-retardant fluid leading to said orifice, a diffuser element positioned downstream from said orifice, and one or more arms extending from said base for supporting said diffuser element, in a position where, when flow of the fire-retardant fluid through said orifice is established, the fire-retardant fluid emerges from said orifice and impinges on said diffuser element to be deflected in a spray pattern,

the improvement wherein

said diffuser element defines two or more slots positioned for through-flow of a portion of the fire retardant fluid emerging from said orifice, said diffuser element having a total cross-sectional area measured in a plane transverse to the direction of the fire-retardant fluid flow from said orifice, and each said slot having a cross-sectional open area,

measured in said plane, equal to at least eight percent of the total cross-sectional area of said diffuser element.

**14.** The fire protection nozzle of claim **13**, wherein said diffuser element and said orifice are coaxially arranged, and each said slot has a long axis disposed substantially transverse to a radial line drawn from the axis of the diffuser element.

**15.** The fire protection nozzle of claim **13**, wherein said diffuser element and said orifice are coaxially arranged, and said diffuser element defines four slots, each said slot having a cross-sectional open area measured in said plane approximately equal to ten percent of the total area of the diffuser element in said plane, and each said slot has a long axis disposed substantially transverse to a radial line drawn from the axis of said diffuser element.

**16.** The fire protection nozzle of claim **13**, wherein said diffuser element and said orifice are coaxially arranged, each said slot has a long axis disposed substantially transverse to a radial line drawn from the axis of the diffuser element, and an open channel is defined between an associated said slot and an outer edge of said diffuser element, said channel being narrower than the associated said slot.

**17.** The fire protection nozzle of claim **16**, wherein said channel has an axis generally aligned with a radial line drawn from the axis of the diffuser element and substantially transverse to the long axis of the associated said slot.

**18.** The fire protection nozzle of claim **16**, wherein said channel has an axis generally aligned with a radial line drawn from the axis of the diffuser element.

**19.** The fire protection nozzle of claim **16**, wherein said channel has an axis substantially transverse to the long axis of the associated said slot.

* * * * *

# UNITED STATES PATENT AND TRADEMARK OFFICE
# CERTIFICATE OF CORRECTION

PATENT NO. : 5,392,993

DATED : February 28, 1995

INVENTOR(S) : Michael Fischer

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Col. 10, Claim 9, line 40, "plant" should be --plane--.

Signed and Sealed this

Fifth Day of March, 1996

Attest:

Bruce Lehman

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks

US005152344A

# United States Patent [19]

Fischer et al.

[11] Patent Number: 5,152,344

[45] Date of Patent: Oct. 6, 1992

[54] FIRE PROTECTION SPRINKLER

[75] Inventors: Michael A. Fischer, W. Kingston; Donald B. Pounder, No. Kingstown; James W. Mears, Warwick, all of R.I.

[73] Assignee: Grinnell Corporation, Exeter, N.H.

[21] Appl. No.: 674,694

[22] Filed: Mar. 25, 1991

[51] Int. Cl.[5] .......... A62C 37/14; A62C 37/11; A62C 37/08

[52] U.S. Cl. .......... 169/37; 169/38

[58] Field of Search .......... 169/37, 39, 38, 40, 169/41, 90

[56] References Cited

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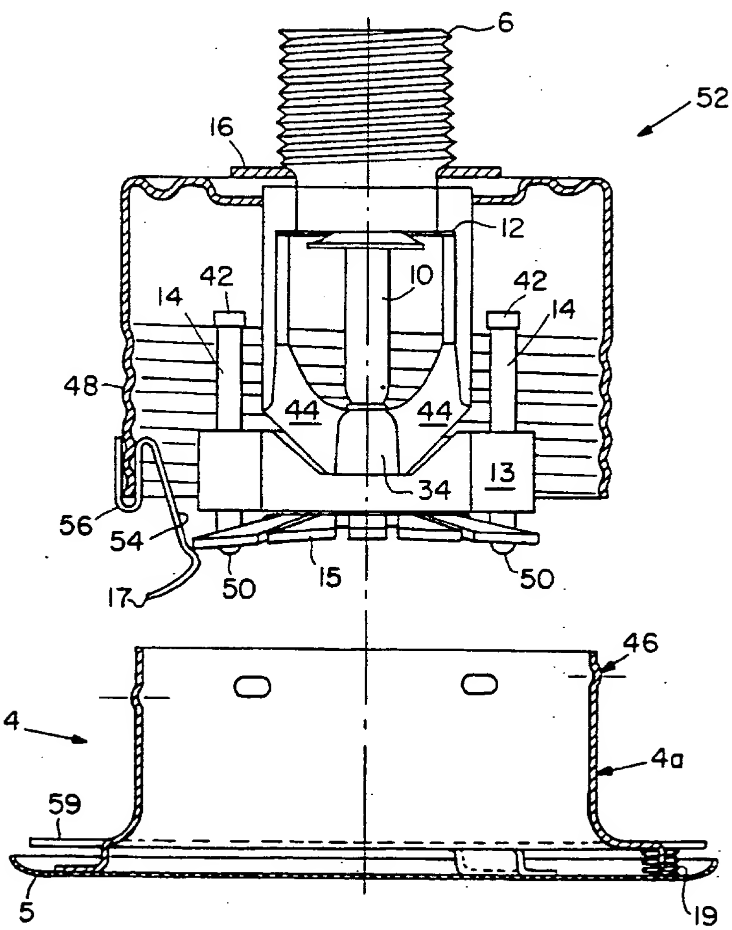
| 4,066,129 | 1/1978 | Anderson | 169/37 |
| 4,880,063 | 11/1989 | Leininger et al. | 169/37 |
| 4,976,320 | 12/1990 | Polan | 169/37 X |

*Primary Examiner*—Margaret A. Focarino
*Assistant Examiner*—James M. Kannofsky
*Attorney, Agent, or Firm*—Fish & Richardson

[57] ABSTRACT

A fire protection sprinkler including a frame having an outlet opening for fire extinguishing fluid and spaced apart frame arms extending from the outlet opening to provide a support at a location spaced from the outlet opening, a sealing member covering the opening, a thermally responsive member connected between the sealing member and the support to seal off the opening during normal temperature conditions and to release the sealing member during abnormally high temperature conditions, an adapter member attached to the frame, one or more pins that are supported by the adapter member, and a deflector that is slidably mounted with respect to the adapter member via the pin or pins. Also disclosed is a clip that retains the deflector in the retracted position in a releasable fashion.

26 Claims, 4 Drawing Sheets



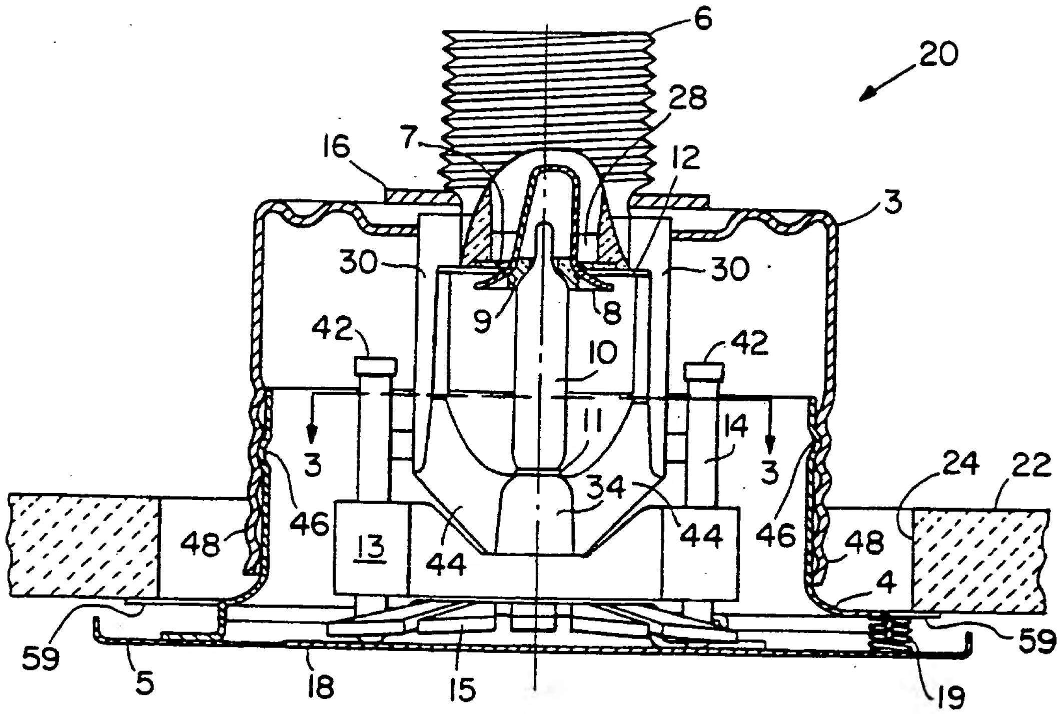

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Fig. 1

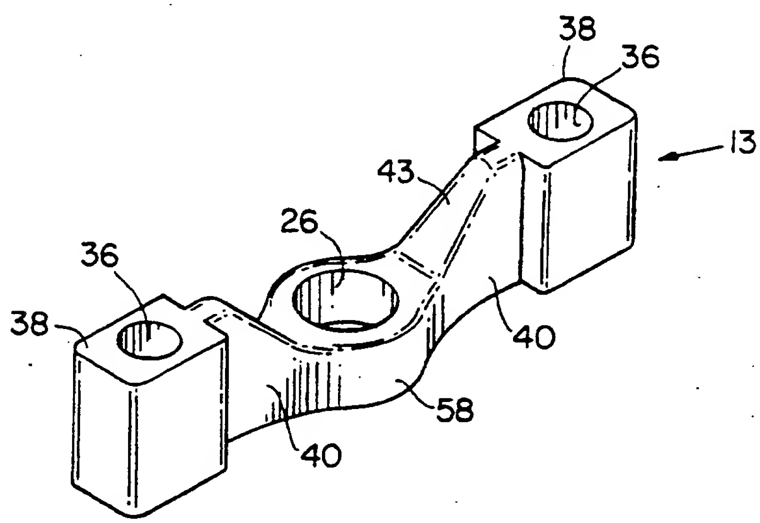
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Fig. 2

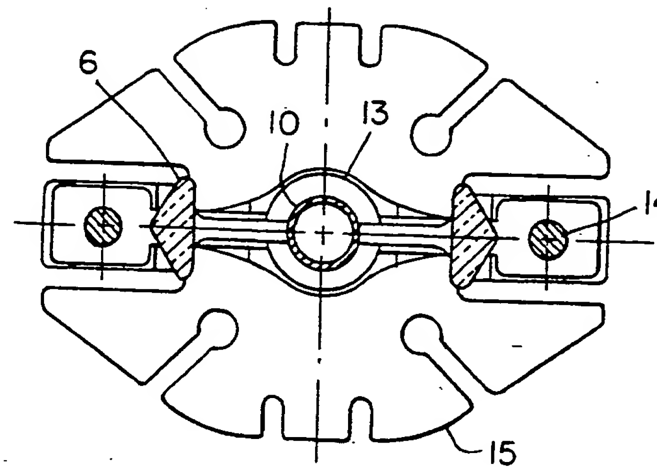


Fig. 3

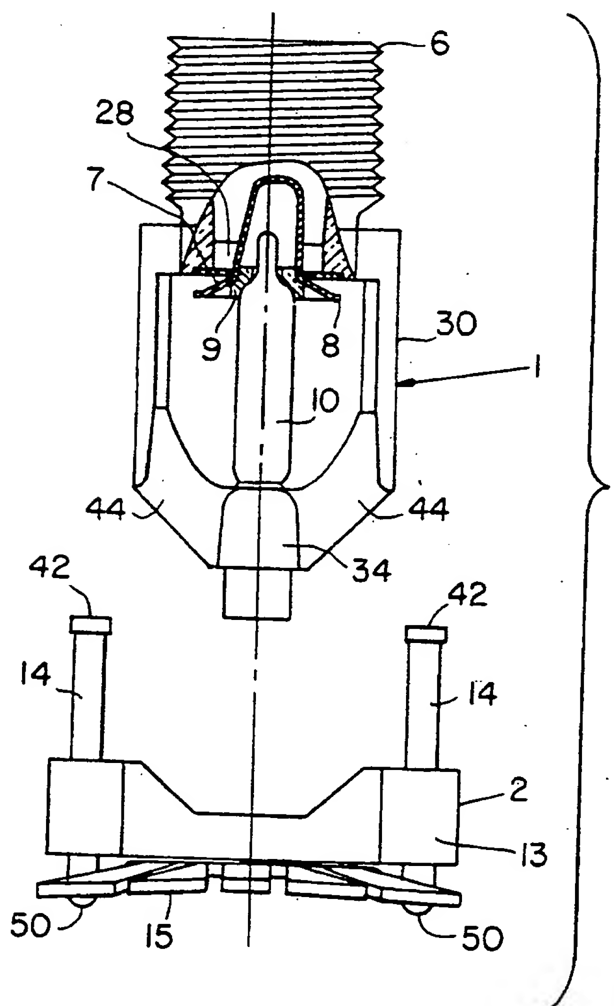


Fig. 4

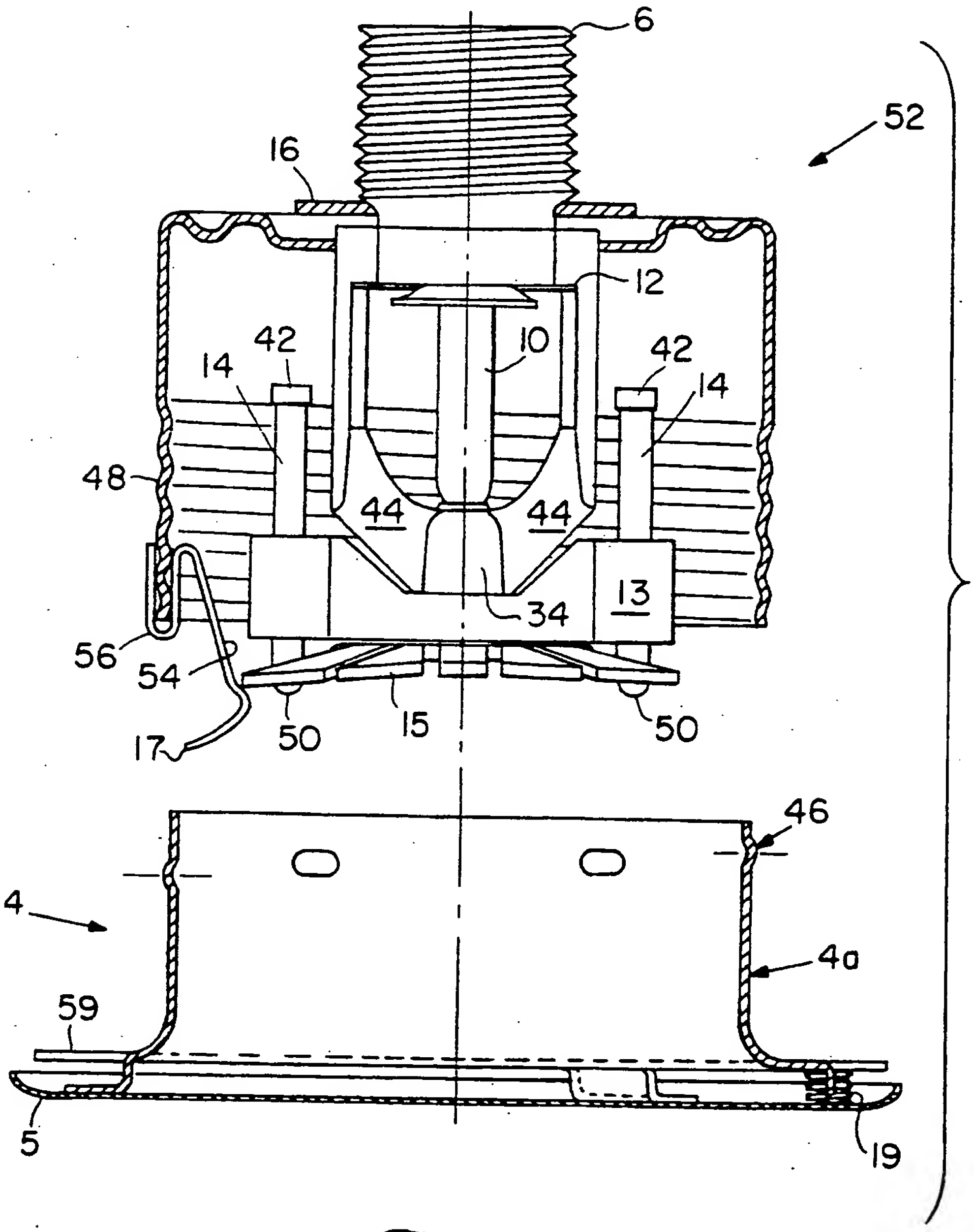


Fig. 5

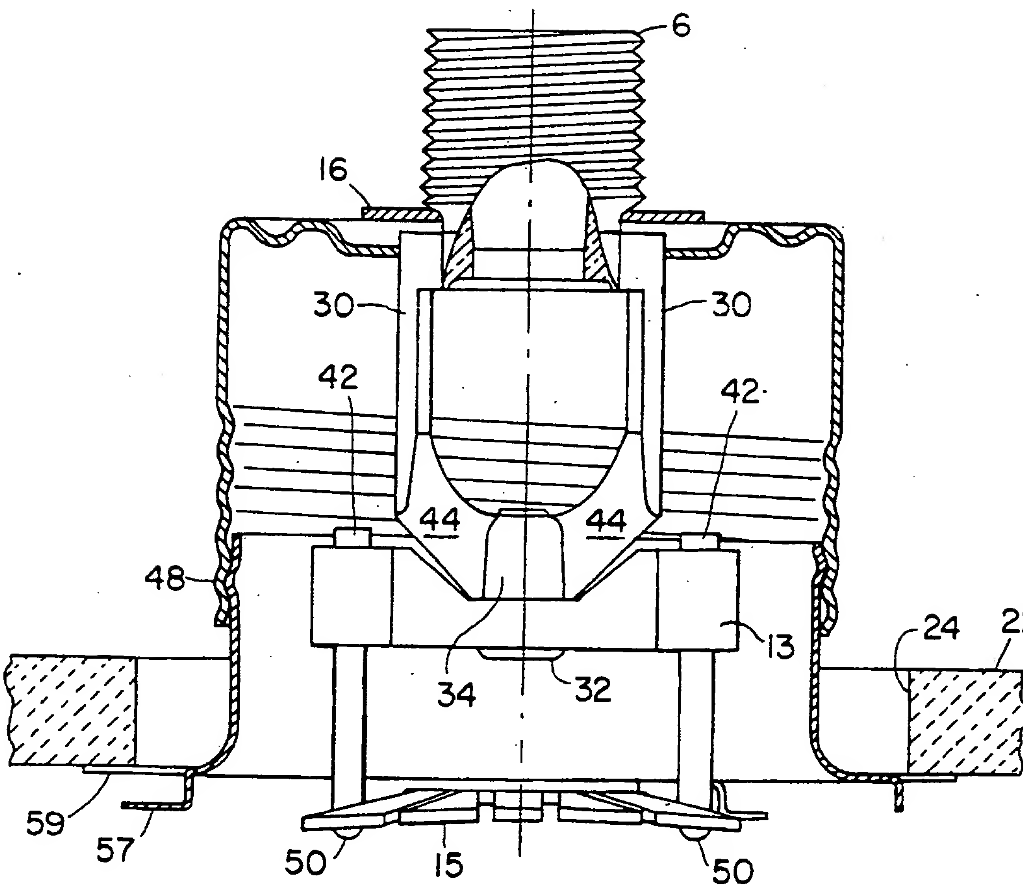


Fig. 6

# FIRE PROTECTION SPRINKLER

## BACKGROUND OF THE INVENTION

The invention relates to concealed fire protection sprinklers having movable deflectors.

Fire protection sprinklers employ deflectors to spread out fire extinguishing fluid to cover a desired area. Some types of fire protection sprinklers employ movable deflectors that are in a retracted position when the sprinkler is inactive and in an extended position when the sprinkler is discharging fire extinguishing fluid.

Such movable deflectors are employed in concealed sprinklers that have covers that are installed flush with the ceiling mounting surface and which extend when the thermally responsive element of the sprinkler is exposed to a predetermined, elevated temperature. The deflector is in a retracted position above the lower surface of the ceiling when inactive and in a lowered position near or below the ceiling when active so as to spread the fluid out over a desired area in the room below, during a fire.

Anderson U.S. Pat. Nos. 4,014,388 and 4,066,129 describe concealed sprinklers with drop down deflectors that are supported by pins that slide within holes passing through arms of sprinkler frames, the pins extending upward into the space between the frame arms when in the inactive position. Leininger et al. U.S. Pat. No. 4,880,063 describes a concealed sprinkler with a drop down deflector that is supported by pins that slide within bosses that extend to the side of and are formed integrally on arms of a sprinkler frame.

## SUMMARY OF THE INVENTION

In one aspect, the invention features, in general, a sprinkler that employs a movable deflector that is slidably mounted via one or more pins for movement between inactive and active positions on an adapter member that in turn is attached to and located outside the frame of the sprinkler. The use of an adapter member permits one to use standard sprinkler parts for the remainder of the sprinkler, and thus avoids the need to design a special frame and do extra machining to the frame arms to provide holes and/or space to accommodate the slide pin or pins into the design.

In preferred embodiments the adapter member is elongated, is attached at a central location to the bottom of the frame directly under the outlet opening of the sprinkler, and has arms that are directly under and extend beyond the arms of the frame. The pins are located outside of the frame arms. The adapter member arms are in close proximity to the bottom surfaces of the arms of the frame (e.g., less than ¼" away and preferably less than 1/16" away). The lower surfaces of the frame arms have portions that are at angles to and extend away from the horizontal, and the upper surfaces of the adapter member arms have portions that are similarly shaped and angled (e.g., within five degrees of each other). The upper surfaces of the adapter member arms are arcuately shaped to help prevent flow detachment from the adapter member arms, and are also streamlined to help prevent flow detachment from the frame arms. The adapter member has a longer vertical dimension at portions where the pin holes pass through than at the central portion connected to the frame, and the pin holes are longer than the width of the pins (preferably greater than 1.5 times the width of the pins and most preferably greater than 2 times the width of the pins). In the preferred embodiment, the adapter member is made of sintered metal, permitting the holes to be incorporated during the sintering process, thus avoiding the need to machine holes, and has a flat bottom. The adapter member is connected to the frame by riveting or staking. The preferred application for the sprinkler is as a concealed sprinkler having a mounting cup that is connected to the frame and a temperature sensitive means such as fusible solder that secures the cover to an enclosure which, in turn, is threaded into the mounting cup when completing installation of the sprinkler. The deflector is longer along a longitudinal deflector axis that intersects and is perpendicular to longitudinal axes of the pins than along a transverse axis.

In another aspect, the invention features, in general, a fire protection sprinkler having a movable deflector that is slidably mounted with respect to the frame and a clip that retains the deflector and thus protects it from damage during shipping and initial installation of the sprinkler, e.g., prior to finishing of the ceiling.

In preferred embodiments the sprinkler has a mounting cup that is connected to the frame and has an end adapted to be threadably connected to an enclosure, and the clip is attached to the mounting cup in a manner that prevents attachment of the enclosure to the cup while the clip is still in place; this guarantees that the clip will not be inadvertently left in place where it might inhibit operation of the sprinkler after the enclosure has been attached. The frame is mounted with the outlet opening directed downward. After removal of the clip, a cover plate is connected to the mounting cup via an enclosure. The clip has a U-shaped portion that engages the bottom edge of the mounting cup. The clip also has an inclined surface that releases the deflector as the deflector is biased to move from its retracted position toward its active position, e.g., by the force of fire extinguishing fluid flowing from the outlet, thus permitting operation of the sprinkler, due to abnormal heat such as caused by fire, after preliminary installation of the sprinkler but before installation of the subassembly consisting of the enclosure and cover. Another feature of this invention involves the retention of the deflector in its retracted position by the cover plate. When the cover plate drops in response to an abnormally high temperature condition, the deflector also drops. Because the deflector moves away from the thermally responsive element which seals the fluid opening, the flow of heated air around the thermally responsive element is increased, and more rapid sprinkler actuation is achieved. A further advantage of this invention is achieved by designing the deflector such that, even if the deflector does not drop below the position in which it rests against the cover, the flow distribution provided by the deflector is not significantly affected. To take full advantage of this feature, the outside area of the deflector is formed with a generally downward shape, and the enclosure has a large enough diameter to ensure that it does not significantly affect the flow of water distributed off of the deflector. When the deflector rests against the cover plate, some heat from the cover plate can be conducted into the deflector as the cover plate heats up. This could slightly retard cover plate actuation time in response to an abnormally high temperature condition. However, this effect is made relatively insignificant by minimizing the contact area between the cover plate and deflector. In the preferred embodiment,

the two surfaces contact only at the lower ends of the pins. Further retardation of heat transfer can be achieved by attaching a thin, thermally insulating member, such as paper, between the deflector and the cover plate.

Other advantages and features of the invention will be apparent from the claims and the following description of the preferred embodiment thereof.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment will now be described.

## DRAWINGS

FIG. 1 is a vertical sectional view, partially broken away, of a fire protection sprinkler according to the invention shown mounted in a ceiling section.

FIG. 2 is a perspective view of an adapter member of the FIG. 1 sprinkler.

FIG. 3 is a horizontal sectional view, taken at 3—3 of FIG. 1, of some components of the FIG. 1 sprinkler.

FIG. 4 is an exploded elevation, partially broken away, of subassemblies of the FIG. 1 sprinkler.

FIG. 5 is a vertical sectional view of the FIG. 1 sprinkler of an enclosure subassembly prior to installation of the latter.

FIG. 6 is a vertical sectional view of the FIG. 1 sprinkler with the cover removed and the deflector in an active position.

## STRUCTURE, MANUFACTURE, AND USE

Referring to the figures, and in particular to FIG. 1, fire protection sprinkler 20 is shown mounted above ceiling section 22 and extending through opening 24 through ceiling section 22. Sprinkler 20 includes a sprinkler subassembly 1 (FIG. 4), drop-down deflector subassembly 2 (FIG. 4), mounting cup 3, and enclosure subassembly 4 (FIG. 5).

Sprinkler subassembly 1 is made of standard sprinkler parts, namely frame 6, spring plate 7, button 8, insert 9, thermally responsive element 10, and loading screw 11. These parts are the same as those in a sprinkler commercially available from Grinnell Corp., Exeter, N.H. under the Designer Sèries trade designation. Frame 6 has outlet opening 28 for discharge of fire extinguishing fluid and spaced frame arms 30 extending down from outlet opening 28 to provide a support for loading screw 11 at a location spaced from outlet opening 28. Spring plate 7 and button 8 cover opening 28 and are supported by thermally responsive element 10 to seal off opening 28 during normal temperature conditions and to release them during abnormally high temperature conditions. Loading screw 11 is threaded upward in a threaded passage through frame boss 34 and loads element 10 from the bottom.

Drop-down deflector subassembly 2 includes adapter member 13, pins 14, and deflector 15. Deflector 15 is made of stamped brass and has a shape designed to provide the desired flow distribution for fire extinguishing fluid. Adapter member 13 is attached at its middle by rolled over portion 32 (FIG. 6) of frame boss 34, which extends through hole 26. Adapter member 13 has two holes 36 at end blocks 38 of adapter arms 40. Adapter member 13 is made of sintered metal (brass or other high strength metal such as stainless steel), including integrally formed holes 36, avoiding the need to have an additional manufacturing step to provide the holes. Pins 14 slide within holes 36, are secured at their lower ends 50 to deflector 15, and have enlarged heads 42 at their upper ends. Pins 14 have a 0.125 ±0.002" outer diameter, and holes 36 have a 0.140±0.0015" inner diameter and are 0.375" long (the same dimension as the height of end blocks 38). These dimensions permit pins 14 and deflector 15 to freely slide owing to gravity when released but to be sufficiently firmly held when in the dropped position during discharge of fluid so as to not hinder the ability of deflector 15 to distribute water. The length of the holes should be generally greater than 1.5 times their diameter and preferably greater than 2.0 times their diameter to provide sufficiently firm support for the deflector when dropped.

The upper surfaces 43 of adapter arms 40 have curved edges, and are in close proximity to (e.g., about 1/32" away from) lower surfaces 44 of the frame arms 30. This acts to reduce disruptions of the flow stream on both frame arms 30 and adapter arms 40, permitting frame arms 30 and adapter arms 40 to act hydraulically as a single surface, as described below. Adapter arms 40 are about 0.100" wide where they connect to end blocks 38 and gradually increase in width as they get closer to the central portion. The edges of the upper surfaces have about 0.040" radii. Upper surfaces 43 are angled at about the same angle as the lower surfaces 44 of frame arms 30; lower surfaces 44 in fact make about a 45 degree angle with the horizontal, and upper surfaces 43 make a slightly smaller angle of about 43 degrees with the horizontal in order to accommodate tolerances associated with frame arms 30.

Mounting cup 3 is retained against frame 6 by E-ring 16. Enclosure 4a has protuberances 46 that engage threads 48 at the bottom of mounting cup 3, and cover plate 5 is secured to flange 57 of enclosure 4a via temperature sensitive fusible solder, not shown, that melts at 135 or 165 degrees F, depending on the operating temperature of the enclosure and cover plate. Spring 19 biases cover plate 5 downward. Enclosure 4a with soldered cover plate 5 and spring 19 form an enclosure subassembly 4 (FIG. 5).

In manufacture, sprinkler subassembly 1 and deflector subassembly 2 can be separately assembled (FIG. 4) and then attached to each other by staking the central portion 58 of the adapter member to the portion of the frame boss which engages adapter hole 26. Alternatively, adapter member 13 can be attached by riveting the portion of the frame boss 34 which extends below the bottom of adapter member 13, so as to provide rolled over portion 32, prior to adding deflector 15; pins 14 would then be inserted through holes 36 and holes in deflector 15, and lower ends 50 of pins 14 would be rolled or crimped over adjacent portions of deflector 15 to secure deflector 15 to pins 14. Mounting cup 3 is then added to the threaded upper end of frame 6 and retained in place using E-ring 16. Clip 17 (made of a strip of spring temper sheet metal) is added to retain deflector 15 in the retracted position, resulting in preliminary assembly 52 shown in FIG. 5.

In installation, the upper threaded end of frame 6 of preliminary assembly 52 is threaded into a threaded fitting of pipes of a water sprinkler system that have been installed near the structural ceiling of a room. Clip 17 retains the deflector during storage, shipping and preliminary installation.

Clip 17 has inclined surface 54 on which deflector 15 rests. In the event of a fire after preliminary installation but before the removal of clip 17, clip 17 would be bent back by the action of downward fluid force on deflector

15, permitting deflector 15 to drop to the active position shown in FIG. 6. Clip 17 also has U-shaped end 56 that engages threads 48, preventing attachment of the enclosure subassembly while clip 17 is still in place.

After clip 17 has been removed, enclosure subassembly 60 (FIG. 5) is added by screwing enclosure 4 into the helical threads of mounting cup 3 until portions 59 of enclosure 4 contact ceiling section 22. Deflector 15 is maintained in its retracted position by cover plate 5. Because contact between deflector 15 and cover plate 5 is limited to the small areas of the bottoms 50 of pins 14, there is little conduction of heat from cover plate 5, which conduction might otherwise delay the dropping of cover plate 5 in response to an abnormally high temperature condition. When an abnormally high temperature condition does exist, cover plate 5 and deflector 15 drop. Because deflector 15 moves away from thermally responsive element 10, the flow of heated air around the thermally responsive element 10 is increased, and rapid sprinkler actuation is achieved. If for some reason deflector 15 does not drop when cover plate 5 drops, the flow distribution provided by the deflector is not significantly affected because the outside area of deflector 15 has a downward shape, and enclosure 4 has a large enough diameter to ensure that it does not significantly affect the flow of water off of deflector 15.

## OTHER EMBODIMENTS

Other embodiments of the invention are within the scope of the following claims.

For example, instead of enclosure 4*a*, cover plate 5 could be connected to mounting cup 3 by an extension that is not continuous but instead has two or more arms.

What is claimed is:

1. A fire protection sprinkler comprising

a frame having an outlet opening for fire extinguishing fluid and spaced apart frame arms extending from the outlet opening to provide a support at a location spaced from the outlet opening,

a sealing member covering the opening,

a thermally responsive member connected between the sealing member and the support to seal off the opening during normal temperature conditions and to release said sealing member during abnormally high temperature conditions,

an adapter member attached to said frame downstream of said frame from said outlet opening,

a pin that is supported by said adapter member, and

a deflector that is slidably mounted with respect to said adapter member via said pin,

wherein said adapter member is elongated, is attached at a central portion thereof to a portion of the frame directly in line with the flow of fluid from the outlet opening of the sprinkler, and has adapter arms that are downstream of said frame arms, and wherein said pin is supported by one of said adapter arms, and further comprising a second pin supported by another of said adapter arms, and wherein said deflector is slidably mounted with respect to said adapter m ember via said second pin.

2. The sprinkler of claim 1 wherein said sprinkler member is adapted to be mounted with said outlet opening directed downward, and said adapter member is located under said frame.

3. The sprinkler of claim 1 wherein said adapter member is made of sintered metal.



4. The sprinkler of claim 1 wherein said adapter member is riveted to said frame.

5. The sprinkler of claim 1 wherein said adapter arms have upstream surfaces that are arcuate in cross section so as to minimize flow detachment therefrom.

6. The sprinkler of claim 5 wherein said adapter surfaces are sufficiently streamlined so as to minimize flow detachment from said frame arms.

7. The sprinkler of claim 1 further comprising a cover plate that is connected to said frame by temperature sensitive releasable means.

8. The sprinkler of claim 7 wherein said temperature sensitive releasable means includes a mounting cup that is connected to said frame, an extension unit is connected to said mounting cup, and a temperature sensitive fusible solder that connects said cover plate to said extension.

9. The sprinkler of claim 8 wherein said extension is an enclosure that is connected to said mounting cup via helical threads.

10. The sprinkler of claim 7 wherein the deflector rests on the cover plate.

11. The sprinkler of claim 10 wherein the deflector is shaped such that fluid flowing from the outlet opening does not substantially contact any surfaces of the temperature sensitive releasable means which attaches the cover plate to the frame even when the deflector is retained at the position which it occupies when resting against the cover plate.

12. The sprinkler of claim 1 wherein said adapter arms are directly downstream of and extend beyond said frame arms, and said adapter member has holes through which respective said pins pass, said pins being located radially outside of said frame arms.

13. The sprinkler of claim 12 wherein said deflector is longer along a longitudinal deflector axis that intersects and is perpendicular to longitudinal axes of said pins than along a transverse axis.

14. The sprinkler of claim 12 wherein said adapter member has a longer dimension in the direction of fluid flow at portions where said holes pass through said arms than at said central portion connected to said frame, said pins have a width, and said holes are longer than the width of the pins.

15. The sprinkler of claim 14 wherein said holes are longer than one and one-half times the width of said pins.

16. The sprinkler of claim 14 wherein said holes are longer than twice the width of said pins.

17. The sprinkler of claim 12 wherein said frame arms have downstream surfaces, and said adapter arms have upstream surfaces that are less than ¼" away from said downstream surfaces.

18. The sprinkler of claim 17 wherein said upstream surfaces are less than 1/16" away from said downstream surfaces.

19. The sprinkler of claim 17 wherein said downstream surfaces of said frame arms have portions that are at acute angles to an axis along the direction of fluid flow out of said outlet opening, and said upstream surfaces of said adapter arms have corresponding portions that have angles with said axis that are within five degrees of angles of said downstream surfaces.

20. The sprinkler of claim 19 wherein said adapter member is made of sintered metal and has a downstream surface that is essentially flat.

21. A fire protection sprinkler comprising

a frame having an outlet opening for fire extinguishing fluid and spaced apart frame arms extending from the outlet opening to provide a support at a location spaced from the outlet opening,

a sealing member covering the opening,

a thermally responsive member connected between the sealing member and the support to seal off the opening during normal temperature conditions and to release said sealing member during abnormally high temperature conditions,

a deflector that is slidably mounted with respect to said frame from a retracted position close to said frame and an active position further away from said frame than said retracted position, and

a clip that is releasably connected to said frame and retains said deflector, preventing movement of said deflector with respect to said frame during normal temperature conditions,

further comprising a mounting cup that is connected to said frame and has an end adapted to be connected to a cover plate via an extension, and wherein said clip is positioned so as to prevent attachment of said extension to said mounting cup while said clip is still in place.

22. The sprinkler of claim 21 wherein said clip has a U-shaped portion that engages the mounting cup at said end.

23. The sprinkler of claim 21 wherein said frame is adapted to be mounted with said outlet opening directed downward.

24. The sprinkler of claim 23 wherein said extension is an enclosure, the connection of the mounting cup to the enclosure adjustably controlling the distance from the cover plate to the frame.

25. The sprinkler of claim 24 wherein said mounting cup is connected to said enclosure via helical threads.

26. A fire protection sprinkler comprising

a frame having an outlet opening for fire extinguishing fluid and spaced apart frame arms extending from the outlet opening to provide a support at a location spaced from the outlet opening,

a sealing member covering the opening,

a thermally responsive member connected between the sealing member and the support to seal off the opening during normal temperature conditions and to release said sealing member during abnormally high temperature conditions,

a deflector that is slidably mounted with respect to said frame from a retracted position close to said frame and an active position further away from said frame than said retracted position, and

a clip that is releasably connected to said frame and retains said deflector, preventing movement of said deflector with respect to said frame during normal temperature conditions,

wherein said clip contacts said deflector at a surface of said clip that is inclined so as to release said deflector as said deflector is biased to move from said retracted position toward said active position due to the flow of fire extinguishing fluid from said outlet opening.

* * * * *

# United States Patent [19]

Fischer et al.

[11] Patent Number: 4,945,948

[45] Date of Patent: Aug. 7, 1990


[54] SIGHT FLOW INDICATOR


[75] Inventors: Michael A. Fischer, Kingston; Roger S. Wilkins, Warwick, both of R.I.

[73] Assignee: Grinnell Corporation, Exeter, N.H.



[21] Appl. No.: 433,490

[22] Filed: Nov. 7, 1989

[51] Int. Cl.[5] ........................ G01F 15/00; F16K 37/00

[52] U.S. Cl. ........................................ 137/559; 116/274; 116/276

[58] Field of Search ................ 137/551, 559; 116/264, 116/273, 274, 276



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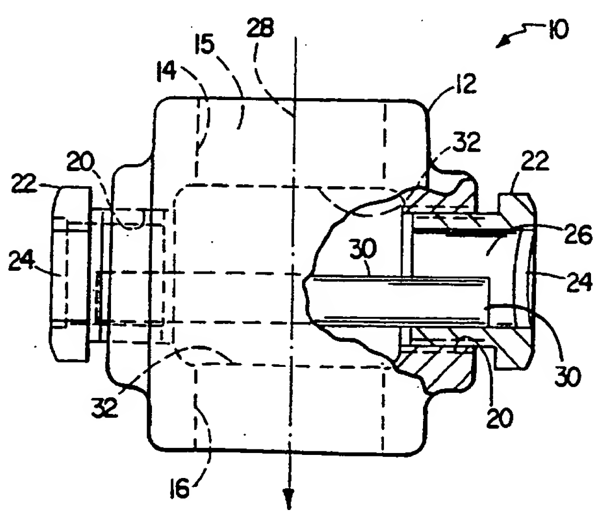
[57] ABSTRACT

A sight flow indicator for visually indicating fluid flow through a conduit including a housing that has an inlet and an outlet and defines a flow passage between the two, the flow passage including a sighting region and a downstream restricted region that has a smaller flow area than said sighting region, a window in the housing providing viewing of the sighting region, and an elongated member that is located in the sighting region that is too long to move from the sighting region into the restricted region and is sufficiently smaller than the sighting region so as to be capable of vibrating about in the sighting region in response to flow of fluid therethrough.


11 Claims, 1 Drawing Sheet



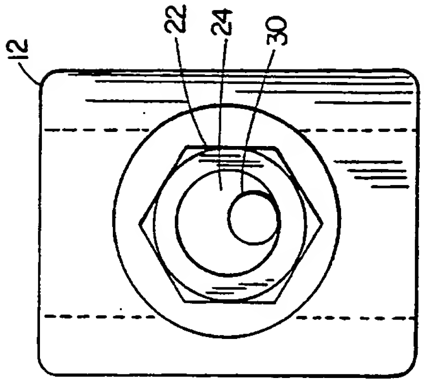



FIG.2

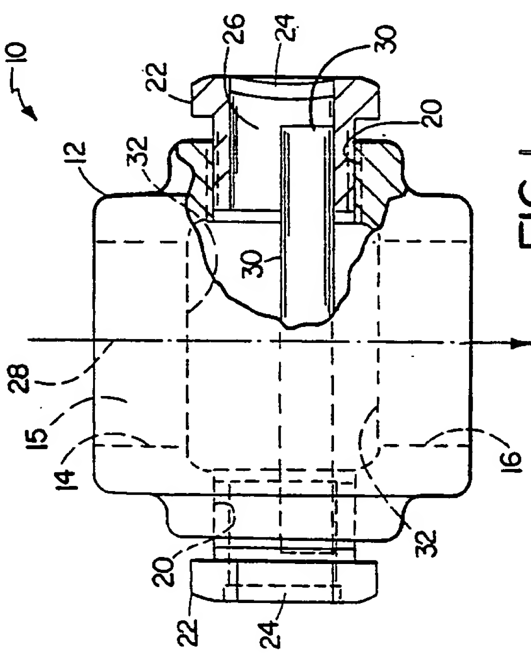



FIG.1

## SIGHT FLOW INDICATOR

### BACKGROUND OF THE INVENTION

The invention relates to sight flow indicators used to visually indicate flow through a conduit.

Sight flow indicators are often connected to a conduit to provide a convenient way of ascertaining whether a fluid is flowing through the conduit, for example, to see if fluid is flowing through an automatic sprinkler system conduit during testing of a fire protection system.

Lewis U.S. Pat. No. 1,179,441 discloses a sight flow indicator that has an inlet and outlet for connection to a pipe and employs two windows located on opposite ends of a sighting region of a flow passage of the indicator to permit viewing of bubbles or particles passing through the passage during flow through it. When turbid water was in the passage of such an indicator in use, a flash light would sometimes be used to assist in viewing flow.

Other sight flow indicators are described in Woodruff U.S. Pat. No. 2,847,969, which shows a flow indicator device consisting of a bladed element (FIG. 1) or three multicolor balls (FIG. 3); Windsor U.S. Pat. No. 2,520,869, which shows a piston that is displaced to indicate a flow condition; and Akhtarekhavari U.S. Pat. No. 4,474,209, which shows an impeller that is rotated within a glass cylinder by fluid flow.

### SUMMARY OF THE INVENTION

It has been discovered that an improved sight flow indicator could be provided by placing an elongated member in a sighting region of a flow passage of the indicator. The elongated member is too long to move from the sighting region into a restricted region downstream of the indicator and is sufficiently smaller than the sighting region and supported so as to be capable of vibrating about in the sighting region in response to flow of fluid therethrough. The elongated member desirably provides an indication of fluid flow when fluid conditions such as transparency, turbidity, lack of entrained particles or bubbles, etc., may make such observations difficult or impossible.

In preferred embodiments, an end of the elongated member is adjacent to a window in the sighting region and tends to sweep across the window and prevent accumulation of material that would otherwise impair viewing through the window. There are normally two windows, and they are located adjacent and outboard of the ends of the elongated member. The elongated member is placed across the flow path (most preferably perpendicular to the direction of flow). The member is made of plastic material (most preferably nylon). The elongated member has a circular cross section and has a diameter that is less than $\frac{5}{8}$ (most preferably between $\frac{1}{8}$ and $\frac{3}{8}$) of the flow diameter of the downstream restricted region and that is less than $\frac{7}{8}$, (most preferably between $\frac{1}{4}$ and $\frac{3}{4}$) of the internal diameter of the sighting region around the ends of the elongated member. The elongated member has a simple shape that provides a minimum of resistance to flow through the passage and, owing to its natural fluid dynamic instability, remains in a vibrating type motion under flow conditions.

Other advantages and features of the invention will be apparent from the following description of a preferred embodiment thereof and from the claims.

### DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** is a front elevation of a sight flow indicator according to the invention.

FIG. **2** is a side elevation of the FIG. **1** indicator.

### STRUCTURE

Referring to FIGS. **1** and **2**, housing **12** of sight flow indicator **10** has threaded inlet **14**, threaded outlet **16**, and flow passage **15** between the two. Housing **12** has a cross configuration with transverse threaded openings **20** that receive threaded sight glass nuts **22**. Threaded sight glass nuts **22** employ glass windows **24** to permit viewing of sighting region **26** between them. The axis of threaded openings **20** is perpendicular to flow axis **28** from inlet **14** to outlet **16**. Elongated member **30** is located in sighting region **26** and has its ends within nuts **22**.

Inlet **14** and outlet **16** are threaded to receive $1\frac{1}{4}$" threaded pipe. Just inward of the threads of inlet **14** and outlet **16** the diameter of flow passage **15** is 1.66" at restricted regions **32** between inlet **14** and sighting region **26** and between sighting region **26** and outlet **16**. Nuts **22** have a 0.94" inner diameter. Elongated member **30** is a circular cross section nylon rod that is 3.62" long and has a diameter of 0.44". Nuts **22** are threaded into their respective threaded openings so that the ends of elongated member **30** are in close proximity to windows **24**, e.g., until there is about $\frac{1}{8}$" total spacing on both sides. Flow passage **15** increases at the transitions between the restricted regions **32** and the transverse threaded openings **20**. Flow passage **15** is thus larger in sighting region **26** than it is in restricted regions **32** such that the presence of the elongated member **30** has no significant effect on the pressure loss due to flow through the housing **12**.

### OPERATION

In operation, indicator **10** is threaded to a conduit, for example, a valve that is located in the drain line of a fire protection sprinkler system and which is used during testing of the system. When fluid flows through flow passage **15**, elongated member **30** is caused to vibrate, providing an easily discernible visual indication to a viewer looking through a window **24**. Elongated member **30** is too long to move from sighting region **26** into the restricted region **32** downstream of the elongated member **30** and is sufficiently smaller than sighting region **26** and supported so as to be capable of vibrating about in sighting region **26** in response to the flow of fluid therethrough. The vibratory movement of the ends of elongated member **30** in the vicinity of windows **24** also acts to wipe the inside surfaces of the windows **24** and helps prevent the accumulation of materials thereon.

Improved visual indication is thus provided by a simple mechanism without substantial hindrance to the flow of fluid through it as the flow area increases at sighting region **26** to make up for flow area blocked by elongated member **30**. Indicator **10** would typically be employed with flow axis **28** in a vertical orientation but would also work in a horizontal orientation or at an angle with the horizontal.

### OTHER EMBODIMENTS

Other embodiments of the invention are within the scope of the following claims. For example, other

shapes and sizes could be employed for the elongated member. Materials other than nylon could be employed for the elongated member. Other means of support of the elongated member in the fluid path and within the sighting region may be used. These support means may include, but are not limited to, having an elongated member with tubular ends bearing on a pin sufficiently smaller in outside diameter with respect to the inside diameter of the recess in each end of the elongated member or suspending the elongated member (i.e., hanging), such that it is capable of moving in the sighting region in response to fluid flow.

The ends of the elongated member adjacent to the view windows may be contrastingly colored or specifically shaped to enhance the visual indication of movement to a viewer looking through a sighting window. The relationship between the physical geometry of the elongated member, the size of the sighting region, the size of the upstream restricted region, and the size of the downstream restricted region may be varied to provide for the desired vibratory movement of the elongated member over a wide range of fluid densities, viscosities, and compressibilities without unduly hindering flow. The degree of vibratory movement of the elongated member can also be further modified by controlling the turbulence of the flow upstream of the inlet of the sight flow indicator.

What is claimed is:

1. A sight flow indicator for visually indicating fluid flow through a conduit comprising
- a housing that has an inlet and an outlet and defines a flow passage between the two,
  - said flow passage including a sighting region and a restricted region that is between said sighting region and said outlet and has a smaller flow area than said sighting region,
- a window in said housing providing viewing of said sighting region, and
- an elongated member that is located in said sighting region and is too long to move from said sighting region into said restricted region and is sufficiently smaller than said sighting region so as to be capable of vibrating about in said sighting region in response to flow of fluid therethrough, and
- wherein said elongated member is disposed in said sighting region such that its longitudinal axis is essentially perpendicular to the direction of flow from said inlet to said outlet.

2. The indicator of claim 1 wherein an end of said elongated member is adjacent to said window.

3. The indicator of claim 2 wherein there are two said windows adjacent to and outboard of the opposite ends of said elongated member.

4. The indicator of claim 1 wherein said elongated member is made of a plastic material.

5. The indicator of claim 1 wherein said elongated member has an external circular cross section.

6. The indicator of claim 5 wherein said housing has an internal circular cross section about the ends of said elongated member.

7. The indicator of claim 5 wherein said restricted region has a circular flow area.

8. A sight flow indicator for visually indicating fluid flow through a conduit comprising
- a housing that has an inlet and an outlet and defines a flow passage between the two,
  - said flow passage including a sighting region and a restricted region that is between said sighting region and said outlet and has a smaller flow area than said sighting region,
- a window in said housing providing viewing of said sighting region, and
- an elongated member that is located in said sighting region and is too long to move from said sighting region into said restricted region and is sufficiently smaller than said sighting region so as to be capable of vibrating about in said sighting region in response to flow of fluid therethrough,
- wherein said elongated member has an external circular cross section,
- wherein said housing has an internal circular cross section about the ends of said elongated member, and
- wherein said elongated member has a diameter that is less than $\frac{7}{8}$ of the internal diameter of said housing about the ends of the elongated member.

9. The indicator of claim 8 wherein said elongated member has a diameter that is between $\frac{1}{4}$ and $\frac{3}{4}$ of the internal diameter of said housing about the ends of the elongated member.

10. A sight flow indicator for visually indicating fluid flow through a conduit comprising
- a housing that has an inlet and an outlet and defines a flow passage between the two,
  - said flow passage including a sighting region and a restricted region that is between said sighting region and said outlet and has a smaller flow area than said sighting region,
- a window in said housing providing viewing of said sighting region, and
- an elongated member that is located in said sighting region and is too long to move from said sighting region into said restricted region and is sufficiently smaller than said sighting region so as to be capable of vibrating about in said sighting region in response to flow of fluid therethrough,
- wherein said elongated member has an external circular cross section,
- wherein said restricted region has a circular flow area, and
- wherein said elongated member has a diameter that is less than $\frac{5}{8}$ of the diameter of said restricted region.

11. The indicator of claim 10 wherein said elongated member has a diameter that is between $\frac{1}{8}$ and $\frac{3}{8}$ of the diameter of said restricted region.

* * * * *

# United States Patent [19]

Martin et al.

[11] Patent Number: 4,893,679

[45] Date of Patent: Jan. 16, 1990


[54] HEAT-RESPONSIVE ELEMENT FOR FIRE PROTECTION SPRINKLERS OR THE LIKE


[75] Inventors: James M. Martin, East Greenwich; Leo W. Fleury, Jr., North Smithfield; Michael A. Fischer, West Kingston, all of R.I.

[73] Assignee: Grinnell Corporation, Exeter, N.H.



[21] Appl. No.: 162,479

[22] Filed: Mar. 1, 1988

[51] Int. Cl.[4] .............................. A62C 37/12

[52] U.S. Cl. .............................. 169/39; 169/42; 169/40

[58] Field of Search .............................. 169/38, 39, 42, 40, 169/37, 41, 90; 403/2, 32



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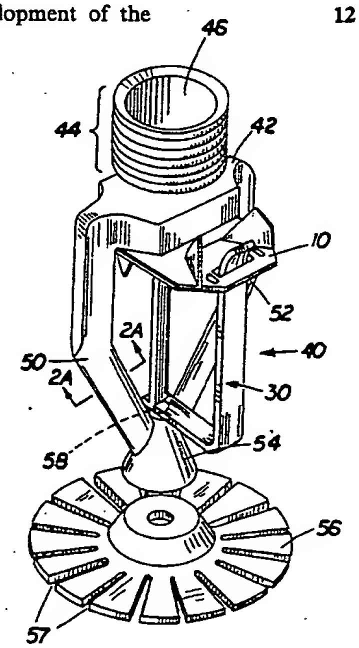
*Assistant Examiner*—James M. Kannofsky

*Attorney, Agent, or Firm*—Fish & Richardson


[57] ABSTRACT


A heat-responsive element has two links joined with a thin solder layer in a face-to-face relationship over an extended surface area. The components of opposed surfaces of the links in contact with the solder layer and the solder layer are adapted to alloy with each other in the regions immediately adjacent each opposed surface to form alloy bonds between the opposed surfaces and the solder layer. The strength of these bonds is greater than the strength of the solder layer. At least the opposed surfaces of the links consist, at least in part, of an alloy-forming amount of nickel, cobalt, chromium or iron, or an alloy of nickel, cobalt, chromium, or iron.


12 Claims, 1 Drawing Sheet



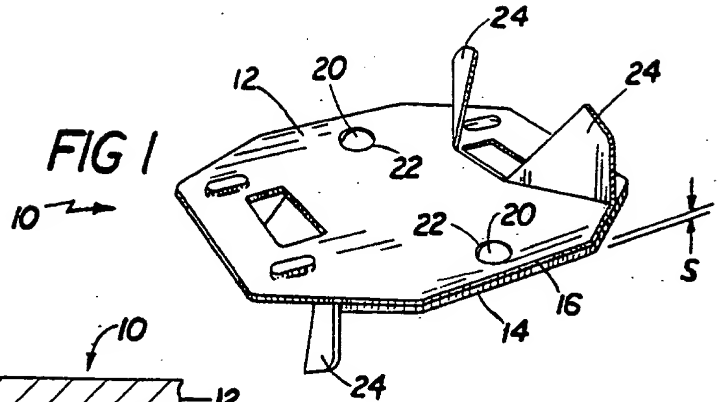


FIG 1

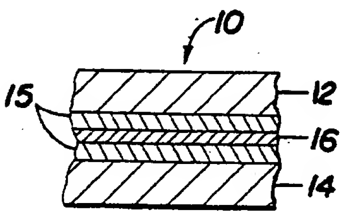


FIG.3

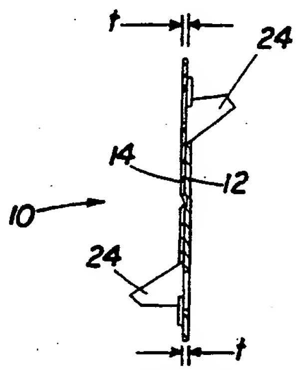


FIG 1B

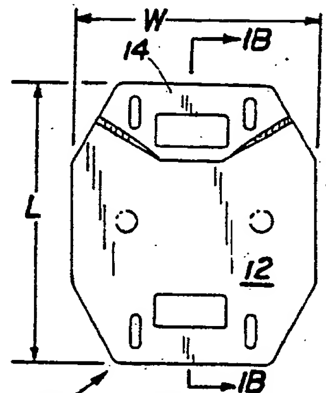


FIG 1A

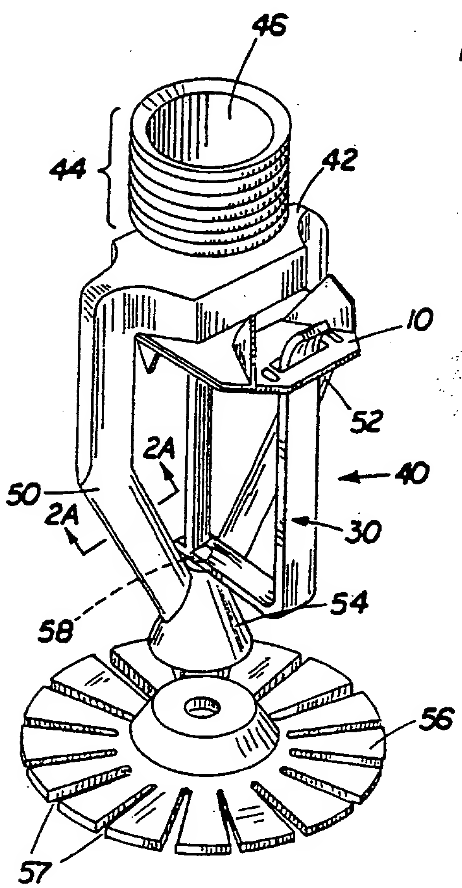


FIG 2

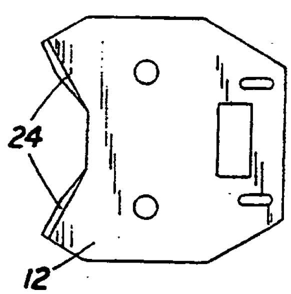


FIG 1C

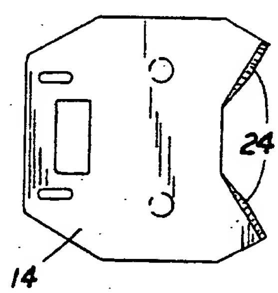


FIG 1D

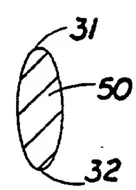


FIG 2A
Prior Art

# HEAT-RESPONSIVE ELEMENT FOR FIRE PROTECTION SPRINKLERS OR THE LIKE

## BACKGROUND OF THE INVENTION

This invention relates to heat-responsive elements.

Heat-responsive elements formed from two pieces of metal attached with a layer of fusible solder have been used in fire protection devices, alarm devices, and the like to permit these devices to be operated automatically at some predetermined critical temperature. When this temperature is reached, the solder joint ruptures, thereby activating the device, e.g., to release fire suppressant material, or to sound an alarm. Pappas et al., U.S. No. 4,170,189 describes a heat-responsive element specifically for use with an alarm. Two thin link plates, at least one made of a material, e.g., stainless steel, which does not alloy significantly with solder, are joined face-to-face with a thin solder layer. The bond between the link plate and solder is weaker than the solder layer itself, and the metal/solder bond ruptures as the critical temperature is neared.

## SUMMARY OF THE INVENTION

In general, the invention features a heat-responsive element that includes two link members joined with a thin fusible solder layer in a face-to-face relationship over an extended surface area. The components of the opposed surfaces of the link members in contact with the solder layer and the solder layer are adapted to alloy with each other in the regions immediately adjacent each of the opposed surfaces to form alloy bonds between these surfaces and the solder layer whose strength is greater than the strength of the solder layer. In this way, when the fuse temperature of the element (i.e., the temperature at which the solder melts, thereby disengaging the link members) is reached, the solder joint is broken through the solder layer, rather than at the metal/solder interface. At least, the opposed surfaces of the link members include an alloy-forming amount of nickel, cobalt, chromium, iron, or an alloy of one or more thereof, with nickel and its alloys being the most preferred.

In other preferred embodiments, when the surfaces of the link are nickel, the solder layer preferably includes tin, cadmium, indium, or a combination thereof, and the alloy bonds include a nickel-tin alloy, nickel-indium alloy, nickel-cadmium alloy, or a combination thereof. The solder layer may also include an alloy-forming amount of nickel, chromium, cobalt, iron, or an alloy thereof.

In still other preferred embodiments, the fuse temperature of the element does not vary from a pre-determined value (based on the composition of the solder layer) by more than 3.5% over the lifetime of the element (as measured by Factory Mutual Research Corp. Approval Standard for Early Suppression, Fast Response, Automatic Sprinklers, page 26, paragraph 5.11 (June 18, 1986), described in more detail below. Furthermore, the Response Time Index of the element preferably is less than 65 $s^{1/2}$ $ft^{1/2}$ (e.g., between 40 and 65 $s^{178}$ $ft^{1/2}$) as measured by Factory Mutual Research Corp. Approval Standard for Early Suppression, Fast Response, Automatic Sprinklers, pages 39–41, paragraph 5.24 (June 18, 1986), described in more detail below.

The invention also features a method of preparing such heat-responsive elements.

According to another aspect of the invention, the heat-responsive element is used in combination with a fire protection sprinkler head of the type including a base having a throat of predetermined cross-section through which a stream of fire retardant fluid can flow.

The invention provides a heat-responsive element useful in a variety of applications e.g., fire sprinklers, fire alarms and heat detectors. The fuse temperature of the element remains essentially constant over the lifetime of the device due to limited diffusion to and from the link members and the ability to restrict the alloy bonds to the area immediately adjacent the opposed surfaces (rather than allowing alloying to extend through the solder layer thickness as a result of diffusion occurring over time). Thus, the element performs reproducibly and reliably over time. Furthermore, by forming alloying bonds between the link members and solder layer that are stronger than the solder layer, failure is limited by the load-carrying ability of the solder-layer, thereby minimizing the chances that the actual operating temperature at which the element is activated will be different from the pre-determined fuse temperature. Moreover, the use of a thin solder layer (e.g., approximately 0.001 inch or less, where this figure includes the thickness of both the unalloyed solder and the alloyed interfacial metal/solder regions) results in faster response time and reduced creep effects.

Other features and advantages of the invention will be apparent from the following description of a presently preferred embodiment, and from the claims.

## PREFERRED EMBODIMENT

We first briefly describe the drawings.

FIG. 1 is a perspective view of a heat responsive element of the invention, while FIG. 1A is a plan view of the element of FIG. 1 and FIG. 1B is a side section view taken at the line 1B—1B of FIG. 1A, and FIGS. 1C and 1D are plan views of the link members of the element of FIG. 1; and

FIG. 2 is a perspective view of a fire protection sprinkler including a heat-responsive element of the invention, while FIG. 2A is a section view along the line 2A—2A of of FIG. 2.

FIG. 3 is a diagrammatic sectional view of an alternative embodiment of a heat responsive element according to the invention.

Referring to FIG. 1, a heat-responsive element **10** of the invention, as described above, features two thin link members **12** (FIG. 1C), **14** (FIG. 1D), e.g., of metal or having a metal surface, having a length, L, approximately $\frac{7}{8}$ inch, and width, W, approximately $\frac{3}{4}$ inch, each with a thickness, t, about 0.006 inch, separated by a thin layer of solder **16**, of thickness, S, approximately 0.001 inch. Link member **14** defines a pair of alignment dimples **20** that are received in corresponding apertures **22** of link member **12**. The ends of each link are deformed into fins **24** for affecting air flow about the link. Thin link plates having a large surface-area-to-thickness ratio are desirable because they conduct heat to the solder faster, thereby decreasing the time it takes for the element to reach its fuse temperature to cause operation of the device into which the element is incorporated. A portion of the solder layer is alloyed with the surfaces of the two plates to form an interfacial alloyed region that bonds the solder layer on both sides to the plates.

Preferred materials for the entire plate or just the surface are nickel, cobalt, chromium, and iron (or alloys having a high, e.g., greater than 40%, content of one of

these elements) for the reasons given below. Surface coatings are preferably formed by sputtering. The solder may also contain one or more of these elements.

Materials that alloy with each other to form an alloy that is stable over the temperature range to which the element will be subjected in actual use are selected by referring to temperature-composition phase diagrams. Such phase diagrams may be found in references such as Staudhammer and Murr, *Atlas of Binary Alloys, A Periodic Index*, Marcel Dekker, Inc. (1973) and Hansen, *Constitution of Binary Alloys*, McGraw-Hill (1958). The most stable alloys will be those having the most negative Gibbs free energy of formation. For example, where the link plate is nickel and the solder is a tin-lead eutectic, a stable alloy will form between the nickel and tin but not nickel and lead. Nickel also forms suitable alloys with cadmium and indium. Cobalt plates may be used with solders containing indium or tin, while chromium may be used with indium-containing solders.

It is also desired that the intermetallic boundary layer alloy be stronger than the unalloyed portion of the solder layer so that when the fuse temperature is reached, the element fails within the solder layer, rather than at the metal/solder interface. The problem with elements that fail at the interface is that the actual temperature at which the alloy bond in the interfacial region fails may be different from the intended predetermined fuse temperature. By restricting failure to the solder layer by making it weaker than the alloy bond, the actual operating temperature is the same as the predetermined fuse temperature because this latter temperature is dependent upon the properties of the solder.

In order for the heat-responsive element to perform reliably in actual operation, it is important that the predetermined fuse temperature remain constant over the lifetime of the element. In many heat-responsive elements, the fuse temperature changes over time because of atomic diffusion between the solder and link plates. Diffusion changes the composition of the solder, which in turn changes the fuse temperature of the element. Because diffusion is a thermally activated process, the rate of diffusion (and thus the change in fuse temperature) increases significantly at elevated temperatures.

There are basically two types of diffusion occurring in a typical heat-responsive element: self-diffusion and inter-diffusion. Self-diffusion involves the thermally activated motion of atoms within a volume of the same type of atoms. The activation energy required for self-diffusion is equivalent to the energy necessary to form a vacancy into which an atom can migrate. Thus, the rate of diffusion is dependent on the concentration of vacancies at any given temperature.

The concentration of vacancies at any given temperature is dependent on the melting point of a particular material. Increasing the melting point results in the formation of fewer vacancies at any given temperature and thus a lower rate of self-diffusion. Therefore, it is desirable to choose materials for the link plates that have relatively high melting points (such materials may also be incorporated into the solder). Nickel (melting point=1455° C.), cobalt (melting point=1495° C.), chromium (melting point=1890° C., and iron (melting point=1535° C.) (and alloys having a high percentage, e.g., at least 40%, of these elements) are particularly useful materials. For example, at any given temperature there are fewer vacancies in nickel than there are in copper (melting point=1083° C.). The activation energy for self-diffusion for nickel, accordingly, is on the order of 1.5 times that of copper.

The second type of diffusion is inter-diffusion, which involves the migration of one atomic species in one direction and a second atomic species in the opposite direction, each down a concentration or activity gradient. Although the activation energy for inter-diffusion differs from that of self-diffusion, the rate of inter-diffusion is also influenced by the rate of vacancy formation. The more vacancies there are in a material, the more places there are into which a second atomic species can migrate. Therefore, the use of relatively high melting point materials also minimizes the rate of inter-diffusion (and therefore the rate of change in fuse temperature).

Diffusion can also be influenced by mechanisms such as electric fields and local states of stress. Residual stresses can be caused by the forming operations used to fabricate the link plates. As temperature increases and recrystallization occurs, the boundaries separating stressed and unstressed areas move; the net effect is a change in the vacancy concentration and rate of diffusion. Such effects are also minimized by using high-melting point elements such as nickel because these elements also have relatively high recrystallization temperatures. For example, the recrystallization temperature of nickel is about 399° C., whereas the value for copper is only about 121° C.

To minimize diffusion even further, the link plates can be provided with a diffusion barrier **15** (FIG. 3), e.g., a material that is solderable with proper fluxing.

The heat responsive element of the invention may be used in conjunction with a typical sprinkler head, e.g., by way of example only, a pendant sprinkler head **40** (FIG. 2), as described in Pounder U.S. Pat. No. 4,580,729, the disclosure of which is incorporated herein by reference. The sprinkler **40** has a base **42** threaded at **44** for connection to the outlet of a fire retardant fluid piping system. The base has a circular inlet and passage **46** which terminates in a circular discharge throat of predetermined cross-section. Extending from the base at opposite sides of the throat are frame arms **50, 52** that join to generally conical central boss **54** to form an arch. The boss is supported by the arms in axial alignment with the throat. Affixed to the base of the boss is a deflector **56** designed with slots **57** for achieving a high percentage of relatively large fluid drops. At the apex of boss **54** is loading pin **58**, provided to receive the lower end of a heat-responsive assembly **30** bearing the heat-responsive element **10** of the invention. Assembly **30**, in standby condition, rigidly retains a valve element that blocks flow of fluid from the throat. Referring to FIG. 2A, in cross-section each of the frame arms has a streamline shape, with a narrow leading edge **31** and a smooth, gradual transition to the region of maximum width and a smooth, gradual transition to the narrow trailing edge **32**.

In operation, when heat has caused the heat-responsive element **10** to actuate and release the valve element from sprinkler throat, fire retardant fluid flows.

The fuse temperature of actuation preferably does not vary by more than 3.5% over the lifetime of the device, as measured by the Accelerated Time Test described in Paragraph 5.11 of the Factory Mutual Approval Standard noted in the Summary of the Invention, above. According to this test, at least 10 sprinklers incorporating the heat element are subjected to the high test temperature selected according to Table 1, below, for a period of 90 days.

TABLE 1

| Sprinkler Nominal Fuse Temperature Rating | Nominal Test Temperature |
|---|---|
| 68–74° C. | 52° C. |
| 93–104° C. | 79° C. |

An automatically controlled, circulating constant-temperature oven is used for the test. At the end of the 90 day period, the fuse temperature of each sprinkler is measured according to Factory Mutual Research Corp. Approval Standard, page 24, paragraph 5.7 (June 18, 1986) as follows.

At least 10 sprinklers incorporating the heat-responsive element are immersed in a vessel containing water or vegetable oil (when fuse temperatures greater than the boiling point of water are anticipated). The vessel is equipped with a source for heating the liquid and means for agitating the liquid. The temperature of the bath is measured with a thermometer calibrated in accordance with ASTM standard E-1-80. The liquid temperature is raised until it is within 20° F. (11.1° C.) of the nominal fuse temperature of the sprinkler. The temperature rise is then controlled at a rate not exceeding 1° F. (0.56° C.) per minute until operation of the sprinkler occurs or a temperature 10 percent above the rated temperature is reached. The temperature of the liquid at the time of operation of each sprinkler is recorded as the fuse temperature.

When subjected to the accelerated testing described above, the fuse temperatures of sprinklers incorporating a heat element prepared from nickel-containing base plates varied by no more than 3.5% from their original fuse temperature ratings.

The Response Time Index (RTI) is a measure of the ability of an element to respond when the fuse temperature is reached by rupturing the solder joint. It is measured according to the plunge test described in Paragraph 5.24 of the Factory Mutual Approval Standard noted in the Summary of the Invention, above. According to this test, at least 12 sprinklers incorporating the heat-responsive element at each nominal fuse temperature rating are plunged into the test section of a tunnel equipped with a mercury plunge switch to start the test and a pressure switch to stop the test. The air flow and temperature conditions in the test section of the tunnel are established as follows.

| Nominal Fuse Temperature Rating of Sprinkler (°C.) | Tunnel Temperature (°C.) | Air Velocity (m/s) |
|---|---|---|
| 68–74 | 197 | 2.56 |
| 93–104 | 197 | 2.56 |

Prior to plunging into the test section of the tunnel, each sprinkler is mounted on a tunnel test section cover and maintained in a conditioning chamber to allow the sprinkler and cover to reach approximately room temperature for a period of not less than 30 minutes. In the case of a sprinkler with symmetrical frame and operating parts, six tests are conducted with the frame arms in a plane perpendicular to the flow of heated air. Where the sprinkler has an asymmetrical thermo-sensitive assembly, the tests are conducted to evaluate the effect of sprinkler position relative to the flow of air (e.g., for a link and lever type sprinkler, six tests are conducted with the link assembly facing upstream and six tests with its facing downstream).

From the response times obtained from the above-described plunge test, the RTI is calculated according to the following equation:

$$RTI = \tau(U)^{\frac{1}{2}}$$

where U is the air velocity in the test section of the tunnel (from the above table); and

$$\tau = -t_r/\ln(1 - \Delta T_{La}/\Delta T_g)$$

where t is the measured response time of the sprinkler;

$\Delta T_{La}$ is the mean fuse temperature of the sprinkler calculated as the difference between the fuse temperature measured according to the test in paragraph 5.7 (described above) and the ambient temperature; and

$\Delta T_g$ is the plunge test tunnel temperature (from the table) minus the ambient temperature.

When subjected to the above-described plunge test, RTI values of sprinklers incorporating a heat element prepared from nickel-containing base plates were less than 65 $s^{\frac{1}{2}}$ $ft^{\frac{1}{2}}$.

The heat-responsive elements are prepared using conventional soldering techniques, temperatures, and times, such as those described in H. Manko, *Solders and Soldering* (2nd ed.-1979).

Other embodiments are within the following claims.

We claim:

1. A heat-responsive element comprising two link members joined with a thin solder layer in a face-to-face relationship over an extended surface area,
   the components of opposed surfaces of said link members in contact with said solder layer and said solder layer being adapted to alloy with each other in the regions immediately adjacent each of said opposed surfaces to form alloy bonds between said opposed surfaces and said solder layer, the strength of said alloy bonds being greater than the strength of said solder layer, and at least said opposed surfaces of said link members comprise an alloy-forming amount of a member selected from the group consisting of nickel, cobalt, chromium and iron, or of an alloy of a member selected from the group consisting of nickel, cobalt, chromium, and iron.

2. The heat-responsive element of claim 1 wherein said opposed surfaces of said link members comprise nickel.

3. The heat-responsive element of claim 2 wherein said solder layer comprises a member selected from the group consisting of tin, cadmium, indium, and a combination thereof, and said alloy bonds comprise a member selected from the group consisting of a nickel-tin alloy, a nickel-cadmium alloy, a nickel-indium alloy, and a combination thereof.

4. The heat-responsive element of claim 1 wherein the fuse temperature of said element does not vary from a pre-determined value by more than 3.5% over the lifetime of the device, as measured by the Accelerated Time Test.

5. The heat-responsive element of claim 1 or 4 wherein the Response Time Index of said element is less than 65 $s^{178}$ $ft^{\frac{1}{2}}$.

6. The heat-responsive element of claim 1 or 4 wherein the Response Time Index of said element is between 40 and 65 $s^{\frac{1}{2}}$ $ft^{\frac{1}{2}}$.

7. The heat-responsive element of claim 1 wherein at least one of said link members is provided with a diffusion barrier.

8. In a fire protection sprinkler head of the type including a base having a throat of predetermined cross-section through which a stream of fire retardant fluid can flow,

the improvement wherein

said fire protection sprinkler head further comprises a heat-responsive element comprising two link members joined with a thin solder layer in a face-to-face relationship over an extended surface area, the components of opposed surfaces of said link members in contact with said solder layer and said solder layer being adapted to alloy with each other in the regions immediately adjacent each of said opposed surfaces to form alloy bonds between said opposed surfaces and said solder layer, the strength of said alloy bonds being greater than the strength of said solder layer, and at least said opposed surfaces of said link members comprises an alloy-forming amount of a member selected from the group consisting of nickel, cobalt, chromium and iron, or of an alloy of a member selected from the group consisting of nickel, cobalt, chromium, and iron.

9. A process for preparing a heat-responsive element comprising joining two link members with a thin solder layer in a face-to-face relationship over an extended surface area under conditions sufficient to form alloy bonds between opposed surfaces of said link members in contact with said solder layer and said solder layer in the regions immediately adjacent said opposed surfaces, the strength of said alloy bonds being greater than the strength of said solder layer, and said opposed surfaces of said link members comprise an alloy-forming amount of a member selected from the group consisting of nickel, cobalt, chromium and iron.

10. A heat-responsive element prepared according to the process of claim 9.

11. A heat-responsive element comprising two link members joined with a thin solder layer in a face-to-face relationship over an extended surface area,

the components of opposed surfaces of said link members in contact with said solder layer and said solder layer being adapted to alloy with each other in the regions immediately adjacent each of said opposed surfaces and said solder layer, the strength of said alloy bonds being greater than the strength of said solder layer, and at least said opposed surfaces of said link members comprise an alloy-forming amount of nickel, or an alloy of nickel.

12. In a fire protection sprinkler head of the type including a base having a throat of predetermined cross-section through which a stream of five retardant fluid can flow,

the improvement wherein

said fire protection sprinkler head further comprises a heat-responsive element comprising two link members joined with a thin solder layer in a face-to-face relationship over an extended surface area, the components of opposed surfaces of said link member in contact with said solder layer and said solder layer being adapted to alloy with each other in the regions immediately adjacent each of said opposed surfaces to form alloy bonds between said opposed surfaces and said solder layer, the strength of said alloy bonds being greater than the strength of said solder layer, and at least said opposed surfaces of said link members comprise an alloy-forming amount of nickel, or an alloy of nickel.

* * * * *

# UNITED STATES PATENT AND TRADEMARK OFFICE
# CERTIFICATE OF CORRECTION

**PATENT NO.** : 4,893,679 Page 1 of 2

**DATED** : Jan. 16, 1990

**INVENTOR(S)** : James M. Martin et al

**It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:**

ON TITLE PAGE: Other Publications

in the Dehaven publication, line 4, the "v" in "vol." should be capitalized; and

in the Pepi publication, line 3, the "v" in "vol." should be capitalized.

Col. 1, line 53, "pre-determined" should not be hyphenated;

col. 1, line 57, delete "(";

col. 1, line 63, "$s^{178}$" should be --$s^{\frac{1}{2}}$--;

col. 2, line 22, "pre-determined" should not be hyphenated;

col. 2, line 43, delete the second occurence of the word "of"; and

col. 5, line 68, "its" should be --it--.

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 4,893,679 

DATED : January 16, 1990

INVENTOR(S) : James M. Martin et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Col. 6, line 65, "$s^{178}$" should be --$s^{\frac{1}{2}}$--;

col. 7, line 21, "comprises" should be --comprise--;

col. 8, line 19, "five" should be --fire--.

**Signed and Sealed this**

**Nineteenth Day of November, 1991**

*Attest:*

HARRY F. MANBECK, JR.

*Attesting Officer* *Commissioner of Patents and Trademarks*

# United States Patent [19]

**Fischer**

[11] **4,405,018**

[45] **Sep. 20, 1983**


[54] **DEFLECTOR WITH SURFACE FOR CIRCUMFERENTIALLY REDISTRIBUTING FLUID FOR IMPROVED SPRAY UNIFORMITY**


[75] Inventor: **Michael A. Fischer**, North Kingstown, R.I.

[73] Assignee: **Grinnell Fire Protection Systems Company, Inc.**, Providence, R.I.



[21] Appl. No.: **278,439**

[22] Filed: **Jun. 24, 1981**

[51] **Int. Cl.**³ .............. **A62C 37/08**

[52] **U.S. Cl.** .............. **169/37**; 169/40

[58] **Field of Search** .............. 169/37, 38, 39, 40, 169/41, 90



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*Primary Examiner*—Joseph J. Rolla
*Assistant Examiner*—Charles C. Compton

[57] **ABSTRACT**


The invention features improved fluid deflection techniques for a pendent-type fire-protection sprinkler head. A first deflecting surface facing generally upward is positioned in the path of fluid emerging from the body of the sprinkler and includes a portion spaced to circumferentially redistribute the fluid to improve uniformity of distribution and deflect at least some of the fluid generally outward. A second deflecting surface positioned radially outward and away from the first deflecting surface receives and controls the distribution of a portion of the outwardly moving water from the first surface; the path of emerging fluid from the sprinkler head body to the first deflector surface extends through an interior opening in the second deflector surface; and the second surface is separated from the first surface by a circumferentially unobstructed region so that the circumferential distribution of the fluid leaving the first surface is not divided as it moves between the first and second surfaces. The dependent structure that supports the first deflecting surface is such that it causes a disturbance in the flow before the flow reaches the first deflecting surface and the first deflecting surface is effective in redistributing the fluid to reduce the uneveness in circumferential distribution which is a result of the disturbance.


**4 Claims, 11 Drawing Figures**

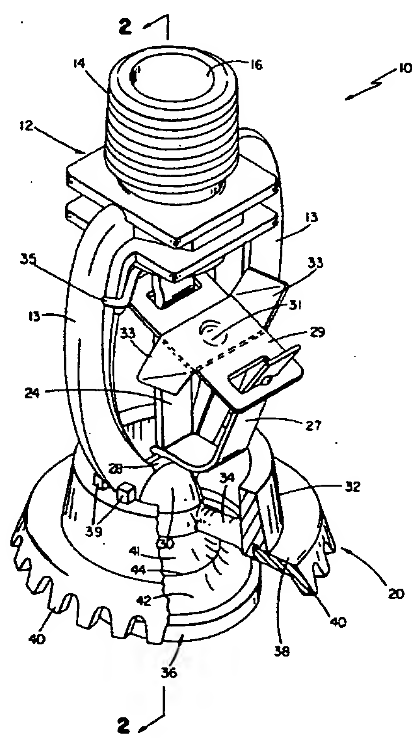
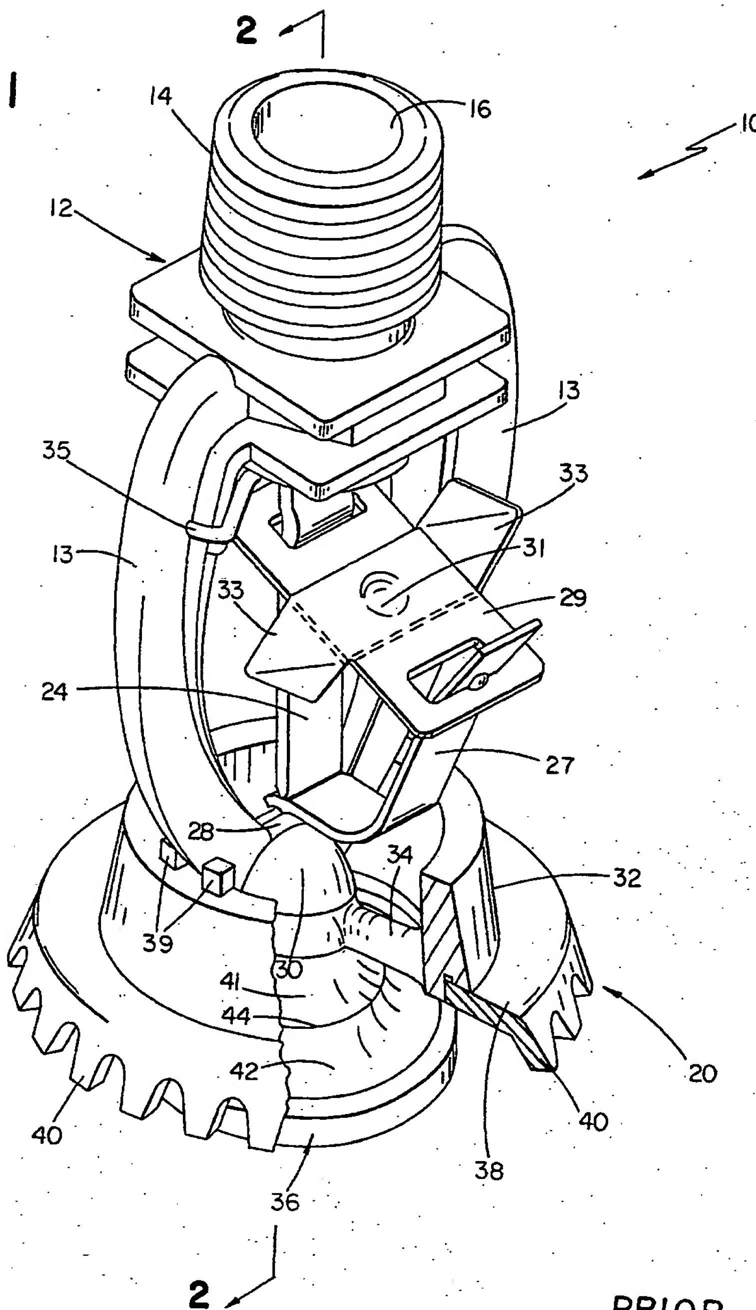


FIG 1




PRIOR ART

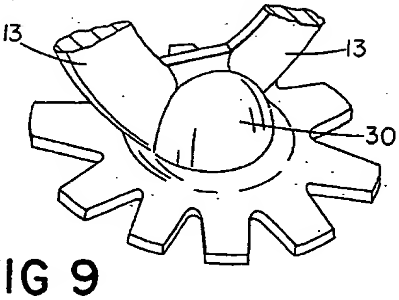
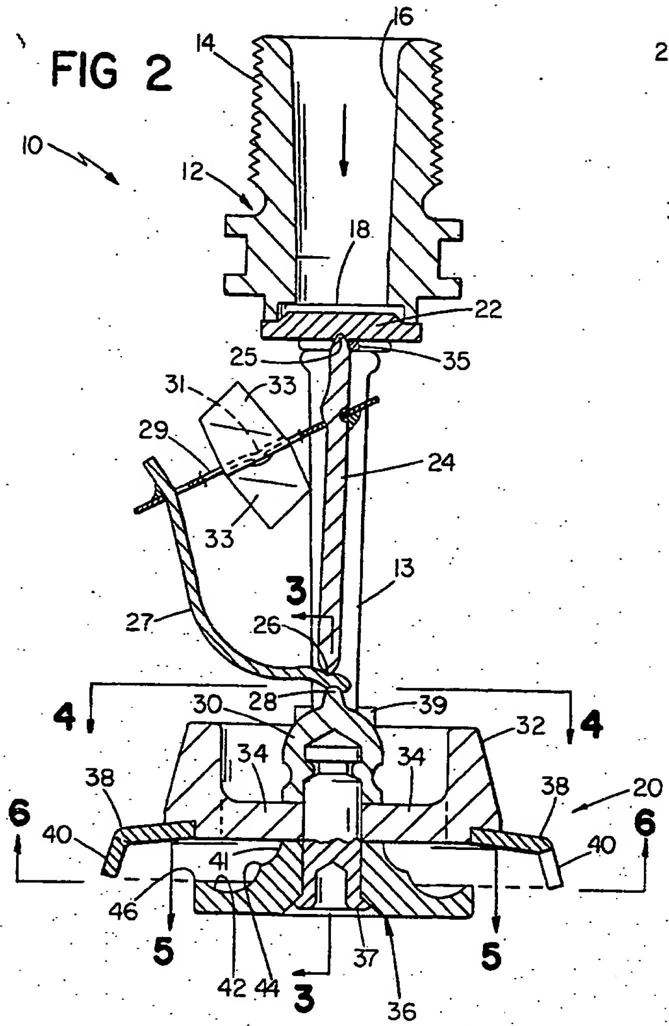



FIG 9

FIG 2



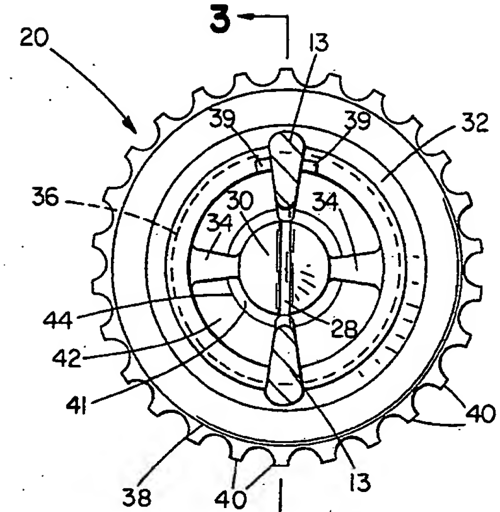




FIG 4

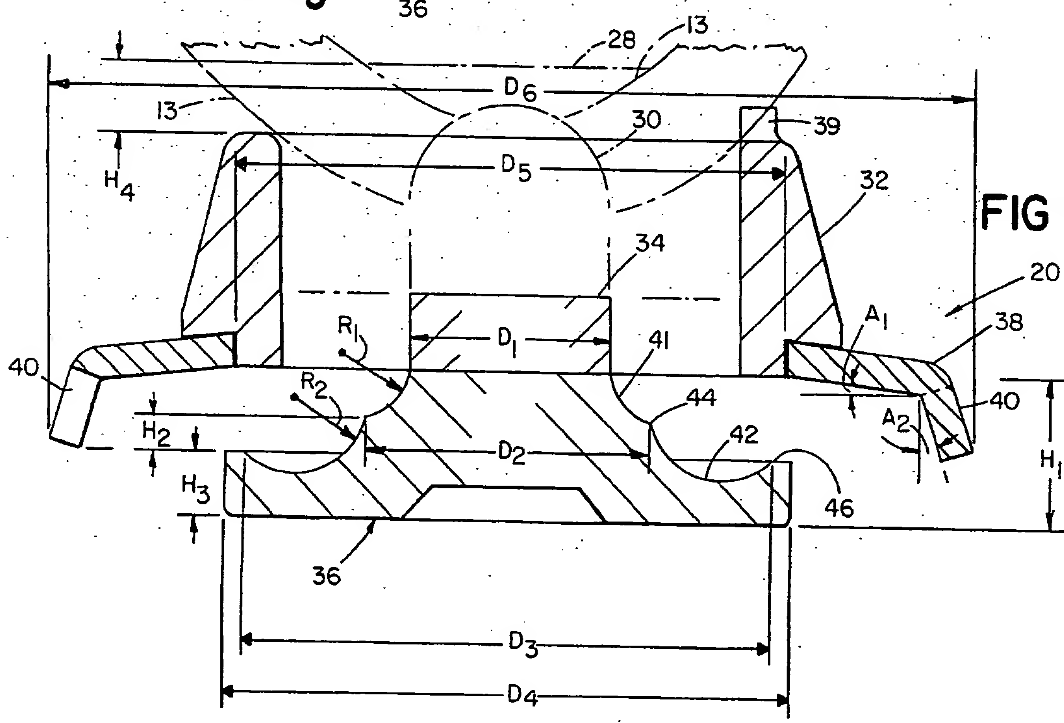



FIG 3

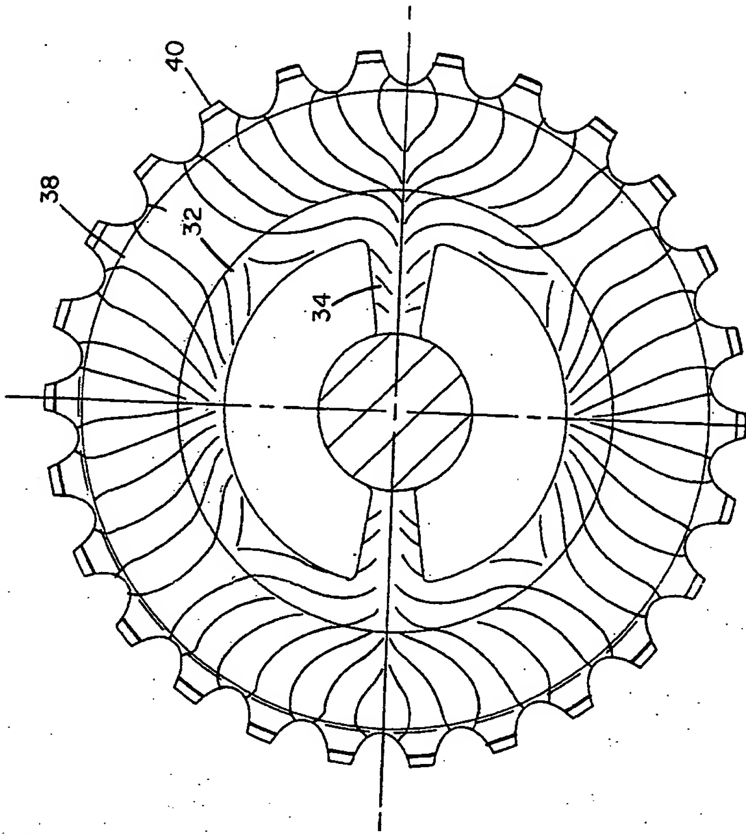



FIG 6

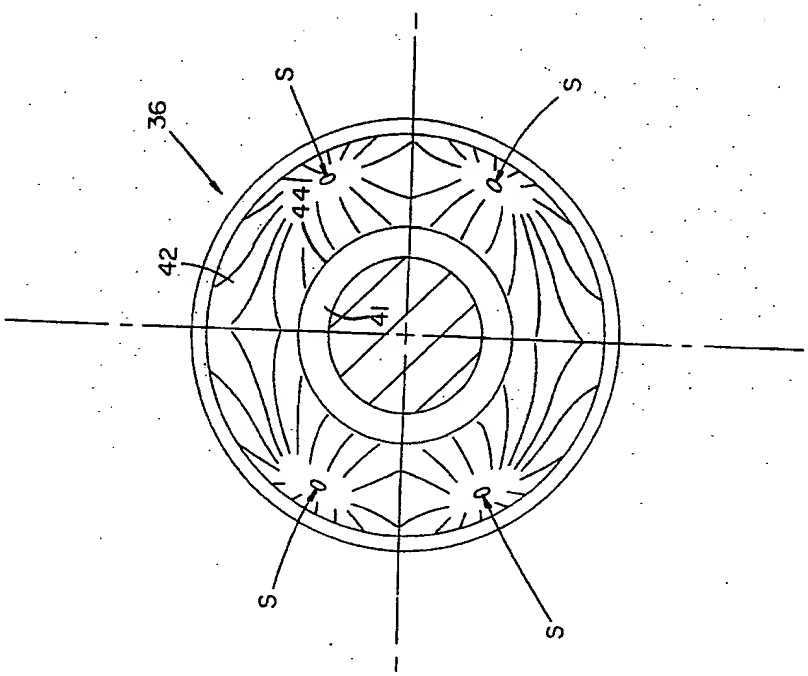



FIG 5

FIG 7

| | | | | | |
|---|---|---|---|---|---|
| .050 | .075 | .060 | .073 | .065 | .066 |
| .066 | .058 | .064 | .062 | .065 | .065 |
| .089 | .133 | .059 | .054 | .114 | .079 |
| .073 | .110 | .060 | .049 | .123 | .071 |
| .079 | .068 | .061 | .064 | .061 | .087 |
| .090 | .070 | .082 | .068 | .055 | .083 |

2FT 2FT

AVERAGE DENSITY IN GPM / FT²

FIG 8 PRIOR ART

| | | | | | |
|---|---|---|---|---|---|
| .085 | .116 | .092 | .123 | .147 | .084 |
| .016 | .050 | .068 | .062 | .051 | .027 |
| .057 | .057 | .106 | .109 | .075 | .097 |
| .038 | .048 | .050 | .056 | .029 | .055 |
| .021 | .063 | .036 | .038 | .070 | .044 |
| .087 | .148 | .107 | .076 | .123 | .082 |

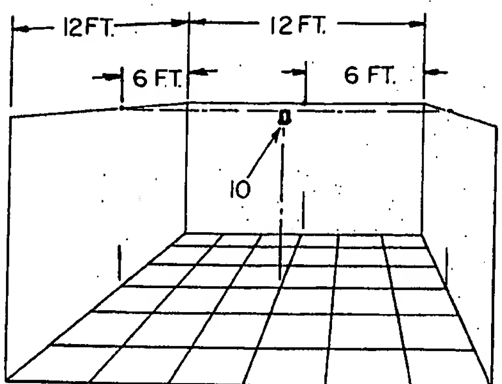


FIG 10

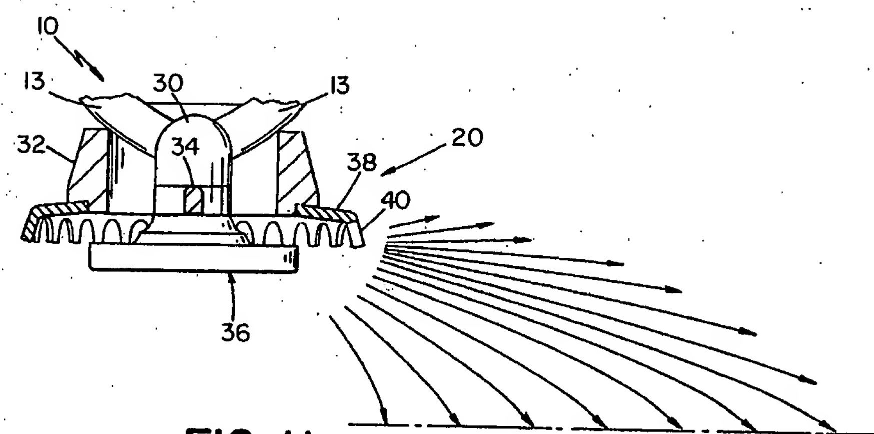


FIG 11

# DEFLECTOR WITH SURFACE FOR CIRCUMFERENTIALLY REDISTRIBUTING FLUID FOR IMPROVED SPRAY UNIFORMITY

## FIELD OF THE INVENTION

This invention relates to pendent sprinkler heads used in automatic fire-protection sprinkler systems.

## BACKGROUND OF THE INVENTION

There exists a need for a pendent type sprinkler head specifically designed to meet the special discharge requirements of residential, automatic, fire-protection sprinkler systems. The special discharge requirements for residential sprinklers are the result of: limited water pressures available for the system; the need to provide coverage, in the case of smaller rooms, with only one sprinkler; and the desire to generate a high percentage of relatively large water drops in the spray.

The water supply to industrial and commercial sprinkler systems is generally fed through relatively large diameter pipes (i.e., 4 inches or greater), and so there are minimal friction losses between the city main and the sprinkler system. In other cases where the available pressure is limited, high-flow producing fire pumps are often used. In residential applications, however, the domestic water supply from the street main is generally fed thru relatively small diameter pipes (i.e. 1½ inches or less) and the emphasis on low cost typically prohibits the use of high-flow pumps. The National Fire Protection Association has indicated that residential sprinkler systems must be designed to help protect against injury, loss of life, and property damage, with as little as 26 gallons per minute (gpm) flow. This criteria limits the number of sprinklers that can effectively discharge in the event of a fire. For the case of a large room (e.g., 14 ft. by 28 ft. and containing four sprinklers), preferably only two of the sprinklers should discharge (i.e. at 13 gpm per sprinkler). Because of this and because only one sprinkler will be called upon to protect a smaller room (e.g. 12 ft. by 12 ft.), a residential sprinkler must provide a much more uniform spray pattern over its entire design area, than is the case for state-of-the-art pendent sprinklers previously developed for industrial/commercial applications.

In order to improve the chance for occupants to escape or be evacuated, a residential sprinkler must prevent or delay flashover (i.e., uncontrolled spread of the fire). This necessitates controlling a fire in its early stages. Furnishings employing petroleum based materials (e.g., synthetic fibers) are a particular problem in this regard since they can result in fast-developing, high-heat output fires. Relatively large water drops are required to penetrate the updrafts and reach the base of this type of fire. Conventional industrial/commercial pendent sprinklers operating with flow-pressure characteristics equivalent to that required in residential applications, produce a higher percentage of small-atomized water drops than that desired in the residential case.

Prior patent applications of Grinnell Fire Protection Systems Company, Inc. have also concerned a residential sprinkler head. Fischer et al. Ser. No. 34,686 concerns an improved fusible link for reducing response time; Fischer et al. Ser. No. 53,262 now U.S. Pat. No. 4,279,309 discloses a non-circular throat for improving spray uniformity. The subject of both applications are employed in embodiments of the present invention and are herein incorporated by reference.

## SUMMARY OF THE INVENTION

The invention features an improved fluid deflection technique for a pendant-type sprinker head. A first deflecting surface facing generally upward is positioned in the path of fluid emerging from the body of the sprinkler and includes a portion shaped to circumferentially redistribute the fluid to improve uniformity of distribution and deflect at least some of the fluid generally outward. A second deflecting surface is positioned radially outward and away from the first deflecting surface, to receive and control the distribution of a portion of the fluid moving outwardly from the first surface; the second deflecting surface having an interior opening and being so positioned that the path of emerging fluid from the sprinkler head body to the first deflecting surface extends through this opening; and the flow paths between said first deflecting surface and the second deflecting surface being circumferentially unobstructed so that the circumferential distribution of the fluid leaving the first surface is not divided as it moves between the first and second surface.

The dependent structure that supports the first deflecting surface is such that it causes a disturbance in the flow before the flow reaches the first deflecting surface and the first deflecting surface is effective in redistributing the fluid to reduce the uneveness in circumferential distribution as a result of the disturbance. Preferably, the first deflecting surface is sized and positioned to oppose the majority of the fluid emerging from the body of the sprinkler.

In preferred embodiments, the first fluid deflecting surface includes an outer circular portion having a vertical cross-section of upwardly concave form and a radially outer lip raised above the lowermost portion thereof to form a circumferential channel. The fluid stream emitted from the body of the sprinkler is divided prior to reaching the first deflecting surface by an apex element to which the first deflecting element is attached and which is preferably supported by two main supporting arms, that extend from the body. Two additional arms radially extending from the apex and preferably perpendicular to the main support arms support the second deflecting element. The fluid stream is thereby divided into four separate streams prior to reaching the first deflector surface and from the point of time of reaching the first deflecting surface, the flow is not divided by supporting structure. The first deflecting surface is therefore effective to reduce the uneveness in circumferential distribution caused by all supports of the deflecting structure. A circular guide channels the separated streams towards the first deflecting surface. A second concave circular channel is formed in the first surface above and radially inward from the first-mentioned concave channel, to vary the outward distribution of the spray to the second deflecting surface. The second deflecting surface has tines at its outer periphery for further separating the spray into a portion that is directed towards the floor and a portion that is directed towards the walls of the room.

In a preferred embodiment the outer lip of the first deflecting surface is generally aligned with the lower edge of tines that define the lower part of the second deflecting surface while the cusp or ridge at the juncture of the first and second concave portions of the first

deflecting surface lies below a ring portion of the second deflecting surface.

In addition to providing a more uniform spray density over the floor and wall areas to be covered by the sprinkler, the invention provides a high percentage of large water drops in a pendent sprinkler, comparable to that which can be achieved with an upright sprinkler. The larger water drops are better able to penetrate the updrafts of fast-developing, high heat output fires.

## PREFERRED EMBODIMENT

A preferred embodiment of the invention will now be described, after first briefly describing the drawings.

Drawings

FIG. 1 is a perspective view, partially broken away, of said embodiment.

FIG. 2 is a sectional view taken at 2—2 of FIG. 1.

FIG. 3 is an enlarged sectional view at 3—3 of FIGS. 2 and 4 showing the deflector assembly of said embodiment.

FIG. 4 is a view at 4—4 of FIG. 2 looking down at the deflector assembly.

FIG. 5 is a view at 5—5 of FIG. 2 looking down at the first deflector element of said embodiment and including diagrammatic streamlines showing the flow pattern on said first deflector.

FIG. 6 is a view at 6—6 of FIG. 2 looking up at the second deflector of said embodiment and including diagrammatic streamlines showing the flow pattern on said second deflector.

FIG. 7 shows spray densities achieved in a test of said embodiment.

FIG. 8 shows spray densities achieved in a test of the same pendent sprinkler but with the prior art deflector of FIG. 9 substituted for the deflector of the invention.

FIG. 9 is a plan view of a conventional prior art deflector for a pendent sprinkler.

FIG. 10 is a diagrammatic perspective view of the 12 ft. by 12 ft. room used for the tests of FIGS. 7 and 8

FIG. 11 is a cross sectional view of the deflector including diagrammatic spray-representing arrows to show the radial spray distribution of said embodiment.

## STRUCTURE

There is shown in FIGS. 1 and 2 an automatic, pendent, fire-protection sprinkler head 10, which has a body 12 with two support arms 13 extending from the body to an apex 30, to which a deflector assembly 20 is attached. Pipe threads 14 on body 12 provide a means for connecting the sprinkler head to a supply of fire-retardant fluid (e.g., the domestic water supply of a home or other residential structure). Through body 12 there extends a passage 16 leading from the fluid supply system to a discharge orifice 18, which is normally closed by a closure element 22 held in place by strut 24.

Strut 24 extends between an abutment groove 25 on the underside of closure 22 and another groove 26 in a resilient lever 27. Groove 26 is slightly offset from the vertical centerline of passage 16. The lever 27 pivots on a swaged ridge 28 located on apex 30 at the centerline of the passage. Lever 27 is held in place by fusible link 29 extending between the top end of the lever and a groove in strut 24.

An ejection spring 35 extending from arms 13 to strut 24 provides a transverse force on the top of strut 24 to assist in clearing away the various elements closing orifice 18 after fusible link 29 has separated in response to a fire.

Fusible link 29 consists of two halves made of copper sheet metal laminated with solder in a lap joint to form a fusible region. Dimple 31 in the fusible region provides added strength. Each half of the link has an air-diverting fin element 33. The link is constructed to respond to the special requirements of residential sprinklers, e.g. four times or more faster than usual industrial or commercial sprinklers (e.g. respond within 6 to 10 seconds under residential test conditions as defined by Underwriters Laboratories, Inc.). For further details for the presently preferred embodiment reference is made to my copending application. Ser. No. 34,686, incorporated by reference herein.

Attached to the base of apex 30 is a deflector assembly. Ring-shaped support 32 (cast) surrounds the apex and is supported therefrom by two integral arms 34. A first circular deflector element 36 (cast or machined) is mounted beneath guide 32 by pin 37 connected to apex 30. A second annular deflector 38 (stamped) is brazed to support 32. A plurality of spaced-apart tines 40 extend generally downward from the periphery of second deflector 38. The upper surface of support 32 is located a short distance below main arms 13 and it has an inner generally cylindrical flow guiding surface. Integral tabs 39 on support 32 straddle one arm 13 to align support arms 34 at essentially 90° with respect to main arms 13.

The first deflector element includes two concave annular surfaces 41, 42, which intersect to define a raised annular cusp or ridge 44. Raised lip 46 surrounds the outer rim of the first deflector surface.

In detail for one of the embodiments of the invention described herein, the upper annular surface 41 is located inwardly of the lower surface, and, in vertical cross section, extends down and outwardly from vertical tangency to the cusp which is located slightly inward from horizontal tangency. The lower annular concave surface begins at the cusp and extends downwardly and outwardly to horizontal tangency, thence upwardly and outwardly to the raised lip.

Referring to FIG. 3, the nominal dimensions of the first and second deflector elements for one embodiment, are as given in the following table (in inches):

| | |
|---|---|
| R1 | 0.10 |
| R2 | 0.12 |
| D1 | 0.34 |
| D2 | 0.48 |
| D3 | 0.9 |
| D4 | 0.96 |
| D5 | 0.95 |
| D6 | 1.58 |
| H1 | 0.15 |
| H2 | 0.06 |
| H3 | 0.11 |
| H4 | 0.19 |

There are twenty-six tines 40 spaced around the periphery of second deflector 38. The tines are angled outward 17° (angle A2 in FIG. 3) from the vertical, to an outside diameter of 1.58 inches at their tips. The lower surface of the second deflector is inclined downward slightly at 6° (angle A1 in FIG. 3) from the horizontal. Second deflector 38 including the tines is stamped from 0.05 inch thick sheet metal.

Both the main support arms 13 (supporting the apex and first deflector from the threaded body) and the arms 34 (supporting the second deflector from the apex) are positioned in the path of the fluid in advance of the fluid reaching the first deflecting surface. The position of the

periphery of the second deflecting surface is arranged to receive fluid that has an outward component.

## OPERATION

In the absence of fire, fusible link **29** provides a restraining force on lever **27** which through mechanical advantage is amplified to produce a much larger upward force on strut **24** to seal orifice **18**.

When link **29** is heated sufficiently to cause the solder laminating its two halves to approach melting temperature (about 140° F.) and thereby lose its strength, the two halves separate, and lever **27** rotates downward, thereby removing the upward force on strut **24** and closure **22**. The strut, closure, and lever are blown away by water exiting from orifice **18**, with spring **35** helping to clear away the various elements. Water strikes arms **13** and apex **30** and is divided into two segregated streams within flow guide **32**. These two streams are then each in turn divided in two upon passing guide support arms **34**, producing four segregated streams, which impinge on concave outer surface **42** of the first deflector element **36**. The impact locations of the four streams are designated with the letter S in FIG. **5**.

An important aspect of the improved spray distribution of the invention is that the shape and position of surface **42** causes portions of the water in each of the streams to spread circumferentially to regions of less density, as suggested by the diagrammatic streamlines in FIG. **5**. This circumferential movement regions the four segregated streams and produces a more circumferentially uniform distribution, i.e., roughly equal amounts of water depart from the compensating element at each circumferential location.

Concave annular surface **41**, which is above and inside surface **42** and has a downward and outward slope, functions to direct fluid to the regions of larger radius from the head. The selected location of cusp **44** in relation to lip **46** and tines **40** of deflector **36** determines the amount of fluid affected by the upper concave surface **41**.

Some of the water leaving first deflector **36** is directed away from the sprinkler head without striking second deflector **38**; the remainder strikes the deflector. The flow pattern on second deflector **38** is suggested by the diagrammatic streamlines in FIG. **6**. There is circumferentially nearly uniform outward flow at the radially outer edge of the deflector, where tines **40** are located, as suggested by the relatively equal spacing and general radial direction of the streamlines (FIG. **6**) at the outer edge. The streamlines in FIGS. **5** and **6** are determined from impressions left by the flow upon paint applied to the first and second deflectors.

As suggested by the arrangement of spray-representing arrows in FIG. **11**, and the flow distribution pattern of FIG. **7**, discussed below, greater percentages of water are directed toward outer circumferences on the floor than to inner circumferences (relative to the vertical center line) to compensate for the larger area of the regions to be covered at the outer circumferences. A portion of the uppermost flow passing between the tines is fragmented into an upwardly and outwardly proceeding cooling mist, which assists in cooling the region just below the ceiling.

FIG. **7** depicts the floor water density distribution achieved in a test of the preferred embodiment when operated at 15 gpm. The sprinkler head **10** was located at the center of a 12 ft. square room as shown diagrammatically in FIG. **10**; its orientation is designated by the locations of apex support arms **13**. The densities given are in units of gpm/ft$^2$. More uniform spray density is achieved; the minimum average density is 0.050 gpm/ft$^2$ over each 2 ft. by 2 ft. sampling area and the maximum is 0.133 gpm/ft$^2$.

To compare these results to the prior art, an identical test was run with a conventional pendent deflector of the type shown in FIG. **9** installed on the apex of the sprinkler head. These results, which represent a typical example of the spray density variation of a conventional pendent sprinkler, are presented in FIG. **8**. It can be seen that much less uniformity was achieved. The minimum density was 0.016 gpm/ft$^2$, and the maximum 0.148 gpm/ft$^2$. With this spray pattern, more flow to the sprinkler would be required in order to provide a preferred minimum average density of 0.040 gpm/ft.$^2$ on all 2 ft. by 2 ft. floor areas. Visual observation of the sprinkler head with the conventional deflector showed a predominantly finer, mist-like spray rather than the predominantly large drops achieved with the preferred embodiment. Furthermore, the conventional pendent sprinkler had a very well defined upper spray boundary which was directed slightly downward forming a pronounced cone of spray below the sprinkler.

By contrast, the preferred embodiment deflected some water upward above horizontal with a combination of large drops and fine spray, thereby providing spray coverage higher on the room walls and filling the region below the ceiling with spray to help cool hot gases there. Cooling the region just below the ceiling helps prevent hot gases from using that region as a conduit for traveling above the sprinkler spray to adjacent areas of the room of other rooms and activating additional sprinkler heads, which reduces the water supply available to the sprinkler heads at the fire site.

A comparison of FIGS. **7** and **8** also shows another advantage of the embodied invention. Note the variation in FIG. **8** average densities for equivalent 2 ft. by 2 ft. areas on opposite sides of main arms **13**. This variation is principally caused by the center of the deflector (FIG. **9**) being not precisely aligned with the longitudinal axis thru the center of discharge orifice **18** due to typical machining variations). The water distribution characteristics of the embodied invention is significantly less sensitive to this manufacturing variation due to the circumferential fluid redistribution effects of the invention (see FIG. **7**).

It can thus be seen that the stringent requirements of a residential sprinkler can be met with parts that do not move during emission of the fire protection spray and are practical and relatively inexpensive to manufacture.

## OTHER EMBODIMENTS

Other embodiments of the invention are within the scope of the following claims. For example, other arrangements could be used for supporting the deflector assembly, including moving the main support arms **13** from apex **30** to support **32** and adding additional arms **34**, as necessary, between support **32** and the apex. The dividing effect of such arms would remain upstream of the first deflecting surface, so that its circumferential redistribution pattern would not subsequently be divided. Other means could be employed for opening orifice **18** in response to a fire; some arrangements would not require the apex **30** support a strut and would thus allow the apex to have a more perfectly conical shape for improved flow distribution. A single concave surface could replace surfaces **40**, **42**, although gener-

ally at a penalty in spray nonuniformity. The deflector could be constructed to provide oblong or other spray patterns, e.g. for use in similarly shaped areas. The sprinklers may be of the reclosing or deluge types, or may be incorporated in a concealed sprinker which drops down upon actuation and then remains stationary during operation.

What is claimed is:

1. In a fire-protection sprinkler head of the pendent type, said head including a body with means for connecting said head to a supply of fire-retardant fluid, a passage through said body for said fluid, a closure for said passage, means for opening said closure in response to a fire, and a spray-forming deflector means supported below said passage by a dependent structure that extends from said body, said deflector means positioned in the path of fluid emerging from said passage, the improvement wherein said deflector means includes:

- a first deflecting surface directly in the path of said emerging fluid and facing generally upward,
  - said first deflecting surface including a portion shaped to circumferentially redistribute fluid to improve uniformity of distribution and deflect at least some of said fluid generally outward; and
- a second deflecting surface positioned outward and away from said first deflecting surface to receive and control the distribution of a portion of the fluid moving outwardly from said first deflecting surface,
  - said second deflecting surface having an interior opening and being so positioned that the path of the fluid from said passage to said first deflecting surface passes through said opening, and
  - the flow paths between said first deflecting surface and said second deflecting surface being circumferentially unobstructed so that the circumferential distribution of said fluid leaving said first deflecting surface is not divided as it moves between said first deflecting surface and said second deflecting surface,
- wherein said first deflecting surface has an outer circular portion having a vertical cross-section of upwardly concave form defining a first concave surface, and
- wherein said first deflecting surface includes a second concave circular surface radially inside of and above said first concave circular surface,
- said first and second concave surfaces are joined at a circular ridge, and
- the location of said ridge and the shape of said second concave surface are selected to influence the radial distribution of fluid in the spray pattern generated by said sprinkler head.

2. The sprinkler head of claim 1 wherein said second deflecting surface includes a generally horizontal ring of larger diameter than said first deflecting surface and a plurality of downwardly directed tines located around the periphery of said ring and wherein said first and second deflecting surfaces are shaped and separated vertically sufficiently to that said circular ridge joining said first and second concave surfaces of said first deflecting surface is positioned below said ring portion of said second deflecting surface, and said tines are spaced generally radially outward from said first deflecting surface.

3. In a fire-protection sprinkler head of the pendent type, said head including a body with means for connecting said head to a supply of fire-retardant fluid, a passage through said body for said fluid, a closure for said passage, means for opening said closure in response to a fire, and a spray-forming deflector means supported below said passage by a dependent structure that extends from said body, said deflector means positioned in the path of fluid emerging from said passage, the improvement wherein said deflector means includes:

- a first deflecting surface directly in the path of said emerging fluid and facing generally upward,
  - said first deflecting surface including a portion shaped to circumferentially redistribute fluid to improve uniformity of distribution and deflect at least some of said fluid generally outward; and
- a second deflecting surface positioned outward and away from said first deflecting surface to receive and control the distribution of a portion of the fluid moving outwardly from said first deflecting surface,
  - said second deflecting surface having an interior opening and being so positioned that the path of the fluid from said passage to said first deflecting surface passes through said opening, and
  - the flow paths between said first deflecting surface and said second deflecting surface being circumferentially unobstructed so that the circumferential distribution of said fluid leaving said first deflecting surface is not divided as it moves between said first deflecting surface and said second deflecting surface,
- wherein said first deflecting surface has an outer circular portion having a vertical cross-section of upwardly concave form defining a first concave surface, and
- wherein said first deflecting surface includes a second concave circular surface radially inside of and above said first concave circular surface and a radially-outer lip raised above the lowermost portion of said first deflecting surface,
- said first and second concave surfaces are joined by a circular ridge,
- a cylindrical surface forms the connection between an apex element and said second concave surface,
- said second concave surface, in vertical cross section, begins at nearly vertical tangency with said cylindrical surface and extends downwardly and radially outwardly to said ridge,
- said first concave surface, in vertical cross section, begins at said ridge and extends downwardly and outwardly through a point of horizontal slope and then upwardly and outwardly to said radially-outer lip.

4. The sprinkler head of claims 1 or 3 wherein said dependent structure supporting said first deflecting surface causes a disturbance in the flow before said fluid reaches said first deflecting surface, and said first deflecting surface is effective in redistributing fluid to reduce the unevenness in circumferential distribution of fluid as a result of said disturbance.

* * * * *

# UNITED STATES PATENT OFFICE
# CERTIFICATE OF CORRECTION

Patent No. 4,405,018 Dated September 20, 1983

Inventor(s) Michael A. Fischer

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Abstract, line 5, "spaced" is changed to --shaped--.

Column 5, line 29, "regions" is changed to --rejoins--.

Column 7, line 5, "sprinker" is changed to --sprinkler--.

Column 7, line 61, "to that" is changed to --so that--.

**Signed and Sealed this**

*Twenty-first* **Day of** *August 1984*

[SEAL]

*Attest:*

GERALD J. MOSSINGHOFF

*Attesting Officer* *Commissioner of Patents and Trademarks*

# United States Patent [19]

Fischer

[11] 4,296,816

[45] Oct. 27, 1981


[54] **HORIZONTAL SPRINKLER DEFLECTOR WITH FLOW LIFTING FORMATION**


[75] Inventor: Michael A. Fischer, North Kingstown, R.I.

[73] Assignee: Grinnell Fire Protection Systems Company, Inc., Cranston, R.I.



[21] Appl. No.: 128,820

[22] Filed: Mar. 10, 1980

[51] Int. Cl.³ ..... A62C 37/08

[52] U.S. Cl. ..... 169/37; 239/498; 239/500; 239/DIG. 1; 239/DIG. 7

[58] Field of Search ..... 169/37, 38, 39, 40, 169/41, 42, 57, 66, 68, 90; 239/498, 500, 504, 518, 521, 522, 523, 524, DIG. 1, DIG. 7


[56] **References Cited**

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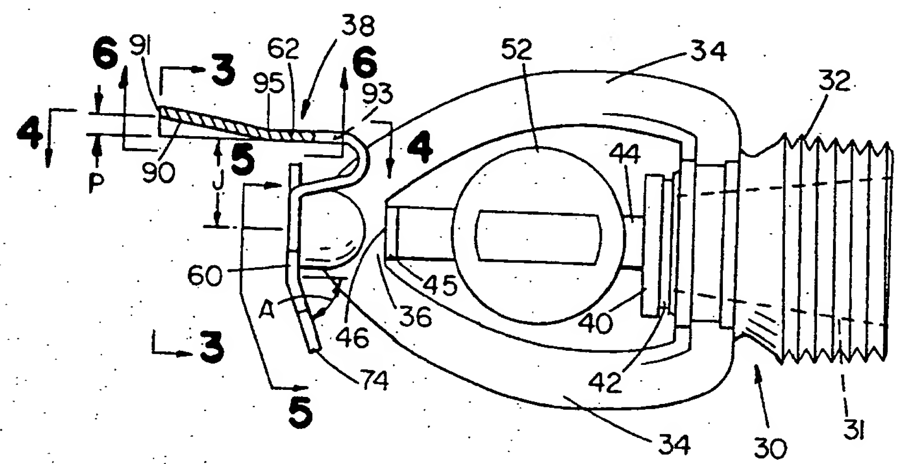
*Primary Examiner*—Robert J. Spar
*Assistant Examiner*—Fred A. Silverberg


[57] **ABSTRACT**


A fire-protection sprinkler head with a deflector having a spray confining surface that includes a deformed area with relatively greater inclination than surrounding undeformed areas so as to selectively lift the flow entering the deformed area and thereby raise its trajectory relative to the flow passing underneath the undeformed areas.


**19 Claims, 7 Drawing Figures**



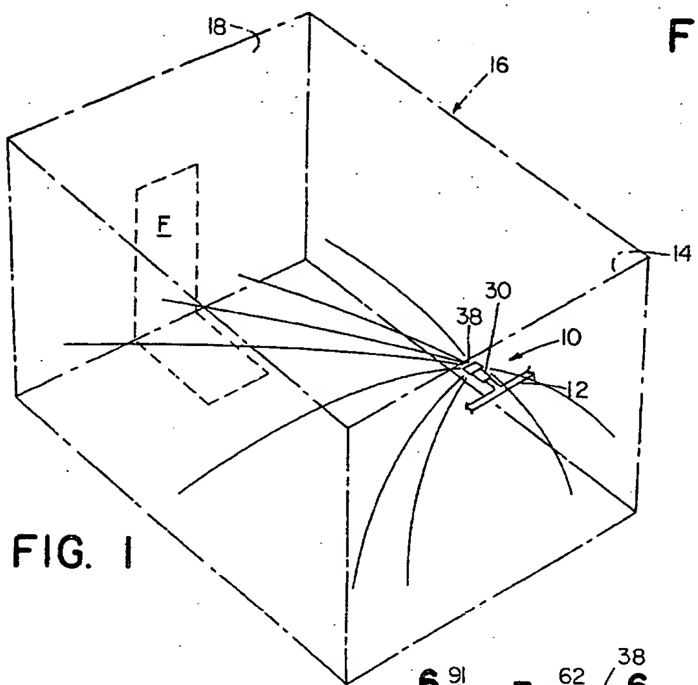



FIG. 1

FIG. 4

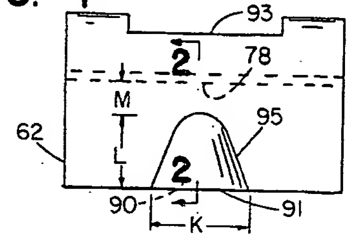
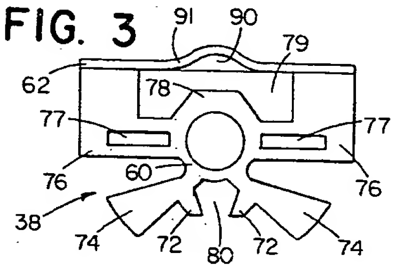



FIG. 3



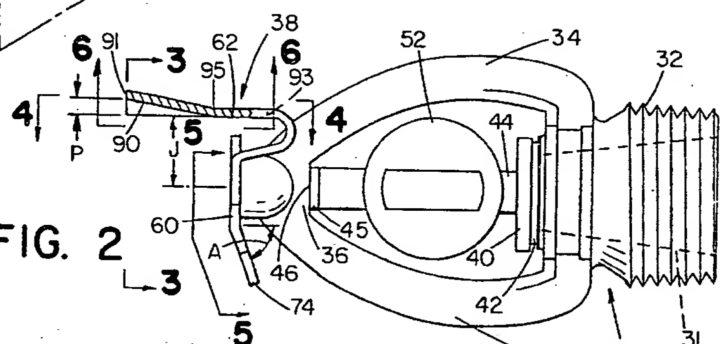




FIG. 2

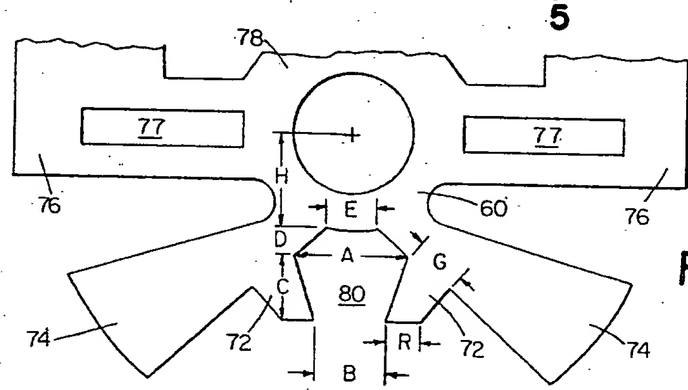



FIG. 5

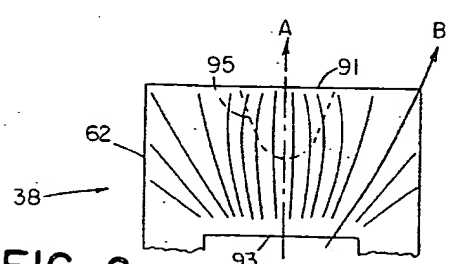



FIG. 6

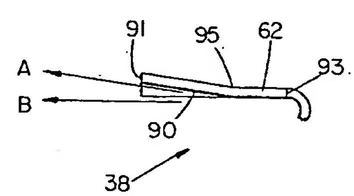



FIG. 7

# HORIZONTAL SPRINKLER DEFLECTOR WITH FLOW LIFTING FORMATION

## FIELD OF THE INVENTION

This invention relates to fire-protection sprinkler heads.

## BACKGROUND OF THE INVENTION

Fire protection sprinkler heads generally include a deflector plate for producing a spray pattern of water (or other fire-retardant liquid). When a fire is sensed, a water stream emerging from the throat of the sprinkler head impinges on the deflector. Often the deflector contains a plurality of fluid deflecting elements (commonly referred to as tines) extending from a central hub, and the tines are relied upon to deflect the water in the desired spray pattern. There are applications, however, in which the deflector includes a surface along which the stream is directed, generally to confine the spray pattern in some way. One such application is the horizontal sidewall sprinkler head, which is generally installed near the top of a wall of a room. Water emerges in a horizontal stream from the throat of such a sprinkler. To aid in distributing the water to the far regions of the room, the upper half of the deflector includes an element that spreads the emerging stream into a fan-shaped spray. Above and extending downstream of this element is a horizontal plate or confining element that further shapes the spray so that it is directed below the ceiling, which may be in some cases within close proximity to the sprinkler head, and towards the far end of the room.

## SUMMARY OF THE INVENTION

Horizontal sidewall sprinklers of the type just described tend to produce a spray pattern with less water density at the far center than at the far sides of the target area. For example, if one sprinkler head is used for a single room, the far center of the room receives less water than do the sides of the room. One cause of the low center density is that centrally-located arms attaching the deflector to the sprinkler head frame tend to obstruct the path of water emerging from the throat. Similarly, the deflector element used to spread the stream into a fan-shaped spray also tends to more greatly obstruct central portions of the spray than laterally outward portions. These obstructions tend to reduce the velocity of central portions of the spray and reduce the water density in the center of the spray. The resulting uneven coverage in far areas limits the room area that can be safely covered by a single sprinkler and means that more than one sprinkler must be used where one might otherwise be enough.

I have discovered that this uneven coverage can be substantially alleviated by upwardly deforming the confining element along a central area extending backward from the downstream end of the element to leave undeformed areas laterally adjacent to and upstream of the deformed area. The undersurface of the upwardly-deformed area is more greatly inclined with respect to the throat axis than are the surrounding undeformed areas, and the amount of inclination is chosen so that water entering the deformed area is selectively lifted upwardly from the flow direction of the remaining water, which flows generally parallel to the undersurface of the undeformed areas. The upward deformation gives a more inclined trajectory to the central portion of the spray, thereby allowing the central portion to reach more distant areas of the room. Also, it appears that some water from outlying regions of the confining surface bend their flow somewhat toward the center increasing the water distribution in that region.

Although I have just described my invention with reference to a horizontal sidewall sprinkler head, the invention can be applied to any sprinkler head in which a fluid stream is directed along and parallel to one surface of a confining element. The deformation is in a direction away from the ordinary parallel flow direction, and water entering the deformation does so because it remains attached to the deformed surface and is thereby lifted (by Coanda effect) from the main stream. The concentrating effect by which the deformed area effectively draws water from other regions is apparently due to the cohesiveness between the molecules of water.

## PREFERRED EMBODIMENT

The structure of a preferred embodiment of the invention will now be described, after first briefly describing the drawings.

## DRAWINGS

FIG. 1 is a perspective view of said embodiment installed on one vertical wall of a room.

FIG. 2 is a side view, partially cross sectioned, of said embodiment.

FIG. 3 is an enlarged frontal view of the deflector taken at 3—3 of FIG. 2.

FIG. 4 is a top view of the deflector taken at 4—4 of FIG. 2.

FIG. 5 is a fragmentary view of the lower half of the deflector taken at 5—5 of FIG. 3.

FIG. 6 is a diagrammatic view taken at 6—6 of FIG. 2, showing the streamlines of fluid flowing along the undersurface of the confining element.

FIG. 7 is a diagrammatic side view of the deflector and of the sprinkler head showing the inclined trajectory given fluid flowing within the upwardly deformed area.

## STRUCTURE

Turning to FIG. 1, there is shown a horizontal sidewall sprinkler **10** installed in supply pipe **12** near the top center of wall **14** of a rectangular room **16** (indicated in broken lines). For reference purposes, wall **14**, on which the sprinkler is mounted, is referred to as the near wall. Wall **18**, opposite the sprinkler, is the far wall.

The sprinkler head is shown in cross section in FIG. 2. Body **30** (a machined bronze casting) has an internal passage or throat **31** for discharging water and threads **32** for attachment to a supply fitting. Integral arms **34** extend outward from body **30** to element **36**, to which is attached deflector plate **38**. Throat **31** (a frustoconical interior surface running along the horizontal axis through body **30**) is normally sealed shut by button **40** and gasket **42**, which are supported by strut **44**. The opposite end of strut **44** rests in a groove in hook **45**, the groove being offset slightly from fulcrum **46** on element **36**, to provide mechanical advantage. Hook **45** is secured to the strut via a key member (not shown), a solder layer (not shown), and bell-shaped heat collector **52**.

Turning to FIG. 3, there is shown a frontal view of deflector plate **38**, which is cut from brass (0.049 to

0.053 inches thick). Extending from central hub portion 60 are a plurality of differently sized and shaped deflector elements 72, 74, 76, 78. Tines 72, 74 are bent back to an angle A (about 70°) (FIG. 2) from the horizontal plane of the central hub. Small tines 72 converge toward each other. Between tines 72 there is formed a slot 80, best seen in FIG. 5. The width of slot 80, over length D (0.06 inches), initially increases for greater radial distances from the hub to a maximum width A (0.26 inches), and then, over length C (0.14 inches), decreases, due to the converging orientation of tines 72, to a width B (0.16 inches). The root dimension E of slot 80 is approximately 0.12 inches. Converging tines 72 each have a dimension G of 0.12 inches at their base and a dimension R of 0.08 inches at their tip. The top of slot 80 is spaced a dimension H of 0.22 inches below the center of hub 60.

Above central hub 60 there is provided a confining element 62, extending outward horizontally (perpendicular to the vertical plane of the hub). The lower surface of the confining element is spaced a dimension J of about 0.39 inches above the center of the hub. The confining element is upwardly deformed at its downstream center to form channel 90, which extends upstream from downstream end 91 of element 62 by a dimension L (0.44 inches), to a point about midway between end 91 and upstream end 93. In plan view (FIG. 4), the boundary 95 between channel 90 and the surrounding flat-undeformed areas is generally parabolic in shape, with the vertex of the parabola at the upstream end of the channel. Undeformed areas surround the channel on both lateral sides and upstream. The undersurface of the channel is arcuate (upwardly concave and tapering, approximating a conical surface) with a radius of about 0.27 inches at downstream end 91, and the centerline of the undersurface is inclined at an angle of from 10° to 12° with respect to the undeformed areas. The channel smoothly merges into the undeformed area, with a fillet radius at boundary 95 of about 0.27 inches, the same as the maximum radius of the undersurface of the channel. The downstream mouth of the channel has a width K of 0.56 inches (which is less than half the downstream width of confining element 62) and a vertical depth (or height) P of about 0.08 inches. The upstream end of the channel is a distance M (about 0.20 inches) downstream of the upstream surface of tine 78 on the deflector hub.

## OPERATION

When the sprinkler is activated (by fusing of the solder layer), strut 44 and button 40 are released, and water (or other fire-retardant liquid) flows through throat 31 in a stream directed at deflector plate 38, which produces and distributes a spray in a generally rectangular pattern to match the size of room 16. The sprinkler is designed to deliver a spray pattern of an acceptable minimum density throughout an area sixteen feet wide and twenty four feet long. Water is primarily directed at the floor and lower wall areas, including the near, side and far walls. As the height and contour of the ceiling above the sprinkler can vary for each installation, the ceiling is not depended upon to deflect the spray.

Each portion of deflector plate 38 serves a separate function in distributing the spray. Lower tines 74 distribute water onto the near wall and adjacent floor area (e.g., the first ten feet of floor). Long rectangular slots 77 distribute water onto the intermediate floor area. Confining element 62, upper tine 78, and aperture 79 control the distribution of water at the far wall and far floor area. Upper tine 78 causes water passing through aperture 79 to spread out in a fan-shaped horizontal spray. The width of aperture 79 determines the width of the horizontal spray. Confining element 62 directs the fan-shaped spray below the ceiling toward the far areas of the room.

Arms 34 and hub 60 tend to obstruct the path of water travelling along the vertical central plane of the sprinkler, and thus tend to reduce the amount of water reaching the center of the far wall and the center of the far floor, the two areas being shown in FIG. 1 as far region F. To compensate for the otherwise low water density in region F, channel 90 is formed in confining element 62. The undersurface of the channel is inclined (by about 11°) from the remainder of element 62 and thereby lifts the central portion of the water emerging from aperture 79 and travelling along the undersurface of element 62. This central portion is thereby given a slightly upward trajectory and the water density in region F is increased, without substantially reducing density in the far regions outside region F, e.g., the far corners.

Channel 90 functions as a Coanda effect surface; the central portion of the stream remains attached to the undersurface of the channel, and is thereby lifted upward. The channel does not function like a notch cut in element 62 to merely permit a stream already travelling in an upwardly inclined direction to continue along its trajectory. Instead it actually lifts upward the central stream, which is travelling horizontally (parallel to the undersurface of element 62). Experiments confirm this conclusion. When a sprinkler was tested with element 62 cut away along boundary 95, the improved performance achieved with the channel was not repeated. Instead the sprinkler performed much the same as it did with no channel and an entirely flat confining element.

FIG. 6 shows the streamlines of fluid travelling along the undersurface of the confining element. Channel 90 is indicated in dotted lines, and two arrows A, B represent the direction of flow leaving the element and headed for the far center and far corners respectively. FIG. 7 shows the inclination of flow directions A and B; flow headed for the far center (arrow A) is inclined upwardly whereas flow headed for the corners (arrow B) is directed horizontally.

Another advantageous effect of channel 90 is that portions of the stream diverging laterally away from straight ahead are caused to follow laterally curved paths that initially diverge but then curve back toward the channel and centerline of the confining element. These curved streamlines are illustrated in FIG. 6. This increases the density of water in the center of the spray, and thereby further increases the spray density reaching the far center of the room. To achieve this streamline curvature it is important to provide a smooth transition at boundary 95 between the channel 90 and the undeformed area and similarly to gradually slope the walls of the channel. (In the embodiment shown, the channel is arcuate in transverse section and thus the walls and roof of the channel are all one arcuate portion.)

Another important consideration in shaping the confining element of the preferred embodiment is that there be no sharp corners, flow restrictions, or other discontinuities that would remove kinetic energy from the flow. Unlike the flow that is deflected toward the intermediate and near regions of the room by the lower portions of the deflector, the flow passing through the upper

portion of the deflector and along the confining element must retain as much kinetic energy as possible in order to reach the far areas of the room. The smoothly shaped channel 90 achieves a redistribution of flow without substantial energy loss. (It should be noted, however, that in other applications wherein spray distances are not as critical or wherein flow energy loss is not as important, the deformation in the confining element need not be as smoothly shaped.)

## OTHER EMBODIMENTS

Other embodiments of the invention are included within the scope of the following claims. For example, such a deformed confining element could be used to selectively alter spray trajectories in sprinklers other than the horizontal sidewall type disclosed herein, and more than one channel could be used on confining element 62 should there be other than one target area requiring greater spray density. Also, the shape of the boundary between the deformed and undeformed areas as well as the contour of the deformed area can be varied in order to achieve the desired density in the target area. The term deformed area is used in a topological sense; channel 90 could be formed by a variety of methods in addition to deforming element 62. Furthermore, more than one sprinkler may be used for a room and the spray pattern of any one sprinkler may be other than rectangular.

## OTHER INVENTIONS

The subject matter relating to converging lower tines 72 was the invention of James W. Mears, and his invention preceded mine.

What is claimed is:

1. In a fire-protection sprinkler head of the horizontal-sidewall type, including a throat through which a horizontal stream of fire-retardant fluid can flow, a deflector spaced from said throat and in the path of said stream for generating a spray into an area, said deflector including a generally planar confining element more nearly horizontal than vertical disposed above the longitudinal axis of said throat for the purpose of confining the upward trajectory of a portion of said stream and a deflector structure below said element for the purpose of deflecting and distributing other portions of said stream in various desired directions, said confining element extending generally longitudinally along the direction of said axis from an upstream end to a downstream end, a portion of said stream being incident upon the undersurface of said confining element and being caused to flow generally parallel to said under surface from said upstream end to said downstream end, the improvement wherein
   said confining element is deformed upwardly along an area extending longitudinally from said downstream end to a region intermediate said upstream and downstream ends, thereby forming
      an upwardly-deformed area and
      generally undeformed areas laterally adjacent to said upwardly-deformed area,
   the undersurface of said upwardly-deformed area being inclined upward relative to the undersurfaces of said generally undeformed areas, and
   said upward inclination being chosen so that a portion of said stream entering said upwardly-deformed area is lifted upwardly from a flow direction generally parallel to the undersurface of said generally undeformed areas to a relatively upwardly inclined flow direction,
   whereby the lifted portion of said stream departs from said confining element with a trajectory more upwardly inclined than the trajectory of other portions of said stream, thereby causing said lifted portion to reach more distant areas from said sprinkler head.

2. The sprinkler head of claim 1 wherein said upwardly-deformed area forms a Coanda-effect surface for lifting said flow.

3. The sprinkler head of claim 1 wherein
   said upwardly-deformed area defines a longitudinally-extending channel,
   said channel is generally upwardly concave in transverse section, and
   the lateral width and vertical depth of said channel increases along the longitudinal axis of said throat from the upstream end to the downstream end.

4. The sprinkler head of claim 3 wherein said lateral width and vertical depth are negligible at said intermediate region where said channel begins and increase uniformly along the longitudinal axis of said throat from the upstream end to the downstream end.

5. The sprinkler head of claim 3 or 4 wherein there is only one said channel and it is centrally located in said confining element directly above the axis of said throat, thereby raising the trajectory of fluid emerging from the center of said confining element.

6. The sprinkler head of claim 5 wherein
   there is at least one support arm extending from a frame portion encompassing said throat to said deflector and said arm is located within a central planar zone which extends vertically above and below the axis of said throat and
   said channel is shaped and sized to increase the distance by which fluid departing centrally from said confining element is sprayed so as to compensate for the reduced flow along the center of said confining element resulting from the blockage of said stream caused by the centrally-located arm.

7. The sprinkler head of claim 5 wherein said intermediate region at which said channel begins is generally midway between said upstream and downstream ends.

8. The sprinkler head of claim 5 wherein the angular inclination of the center of said channel with respect to said undeformed areas is between 5 and 15 degrees.

9. The sprinkler head of claim 5 wherein said undeformed areas are generally planar.

10. The sprinkler head of claim 5 wherein said channel is arcuate in transverse section.

11. The sprinkler head of claim 5 wherein the boundary dividing said channel from said undeformed areas is generally parabolic in shape with the open end at said downstream end and the vertex at said intermediate region.

12. The sprinkler head of claim 3 wherein
   said channel has two walls that smoothly merge into said undeformed areas on either lateral side and
   said merger is sufficiently smooth and the slope of said walls along the lateral direction is sufficiently gradual to cause portions of said stream flowing underneath said confining element to follow laterally curved paths further downstream that initially diverge laterally but curve back toward said channel and toward the center line of said confining element.

13. The sprinkler head of claim 12 wherein there is only one said channel and it is centrally located in said confining element directly above the axis of said throat, thereby raising the trajectory of fluid emerging from the center of said confining element and increasing the amount of water so emerging from the center as a result of said lateral redirection of flow toward said channel, whereby a greater spray density can be achieved in the distant central region of said area, said distant central region being that region longitudinally ahead of said sprinkler head and at the furthest longitudinal distance from said sprinkler head.

14. The sprinkler head of claim 1 or 3 wherein said deflector further comprises a fluid deflecting element upstream of and below said confining element for spreading a portion of said stream emerging from said throat into a spray that is incident upon said undersurface of said confining element at a region upstream of said deformed area.

15. The sprinkler head of claim 3 wherein said channel width at said downstream end is less than half the width of said confining element at said downstream end.

16. The sprinkler head of claim 1 wherein said deformed area is upwardly concave in transverse section and tapering longitudinally so as to be substantially conical.

17. The sprinkler head of claim 1 wherein said undeformed areas include an upstream of said deformed area.

18. In a fire-protection sprinkler head, including a throat through which a nearly horizontal stream of fire-retardant fluid can flow, a deflector spaced from said throat in the path of said stream for generating a spray into an area, said deflector including a generally horizontal confining element disposed above the longitudinal axis of said throat of said stream and a deflector structure below said element for the purpose of deflecting and distributing other portions of said stream in various desired directions, said confining element extending generally longitudinally along the direction of said axis from an upstream end to a downstream end, a portion of said stream being incident upon the undersurface of said confining element and being caused to flow generally parallel to said under surface from said upstream end to said downstream end, the improvement wherein

said confining element is deformed upwardly along an area extending longitudinally from said downstream end to a region intermediate said upstream and downstream ends, thereby forming
an upwardly-deformed area and
generally undeformed areas laterally adjacent to said upwardly-deformed area,

the undersurface of said upwardly-deformed area being inclined upward relative to the undersurfaces of said generally undeformed areas, and

said upward inclination being chosen so that a portion of said stream entering said upwardly-deformed area is lifted upwardly from a flow direction generally parallel to the undersurface of said generally undeformed areas to a relatively upwardly inclined flow direction,

whereby the lifted portion of said stream departs from said confining element with a trajectory more upwardly inclined than the trajectory of other portions of said stream, thereby causing said lifted portion to reach more distant areas from said sprinkler head.

19. The sprinkler head of claim 18 wherein there is a single channel centrally located in said confining element.

* * * * *

# United States Patent [19]

**Fischer et al.**

[11] **4,279,309**

[45] **Jul. 21, 1981**


[54] **SPRINKLER HEAD WITH NONCIRCULAR THROAT**


[75] Inventors: **Michael A. Fischer**, North Kingston; **James W. Mears**, Warwick, both of R.I.

[73] Assignee: **Grinnell Fire Protection Systems Company, Inc.**, Providence, R.I.



[21] Appl. No.: **53,262**

[22] Filed: **Jun. 29, 1979**

[51] **Int. Cl.**[3] .................. **A62C 37/12**

[52] **U.S. Cl.** .................. **169/37**; 169/39; 239/591

[58] **Field of Search** .................. 169/37, 38, 39, 40, 169/41, 57, 90; 239/589, 590, 590.5, 591, 601, DIG. 1



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*Primary Examiner*—Stanley H. Tollberg
*Assistant Examiner*—Fred A. Silverberg



[57] **ABSTRACT**

A fire-protection sprinkler head having a base from which fire-retardant fluid emerges in a stream, a deflector plate spaced from the base for deflecting the stream into a spray pattern, and a throat in the base with a noncircular cross section selected to vary the shape of the stream and thereby vary the spray pattern.

**9 Claims, 9 Drawing Figures**

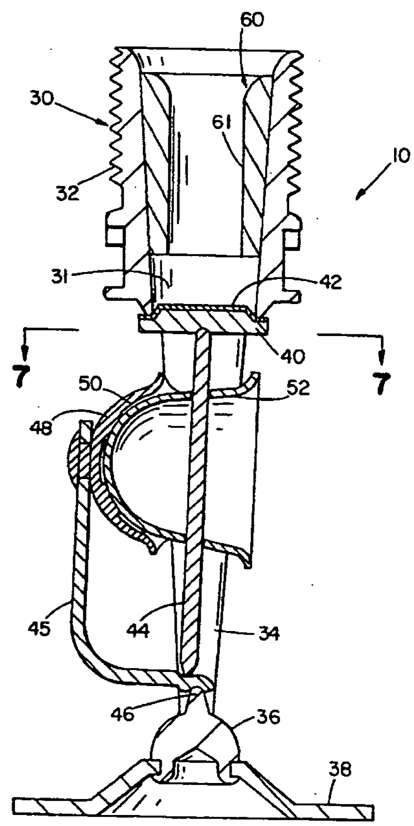



FIG 1

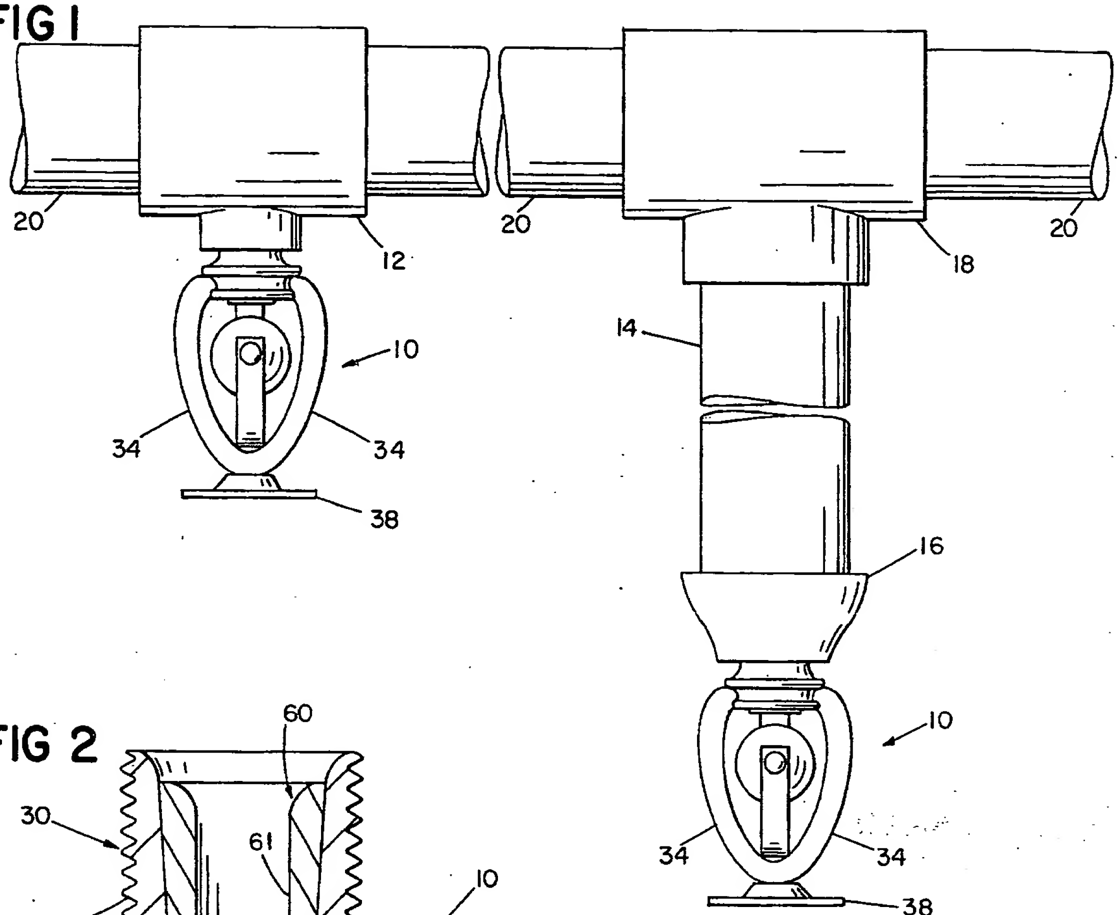
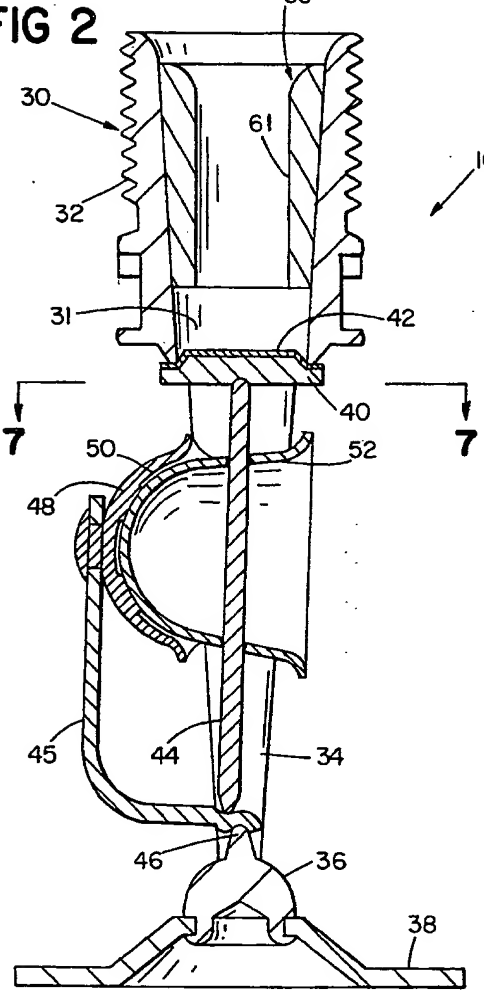



FIG 2



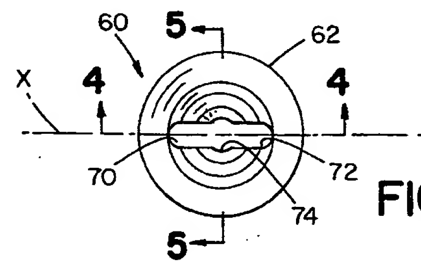




FIG 3

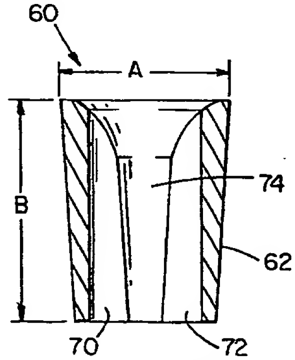



FIG 4

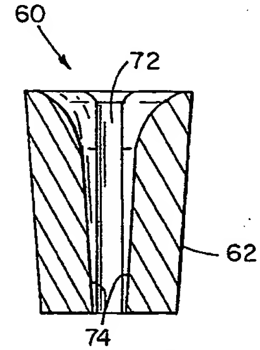



FIG 5

FIG 6b

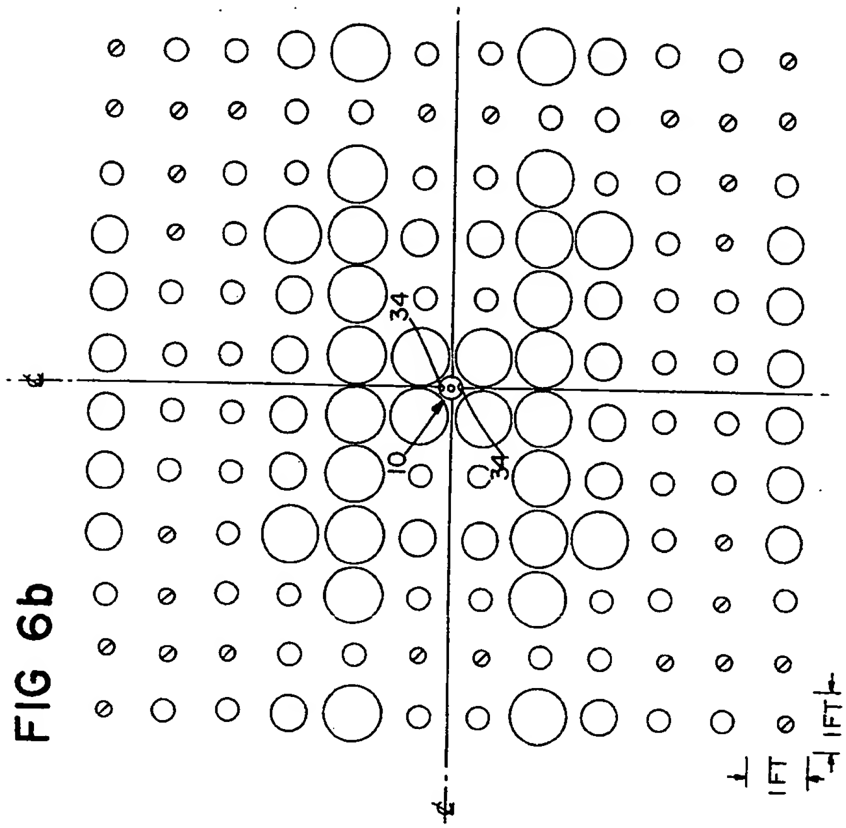



FIG 7a

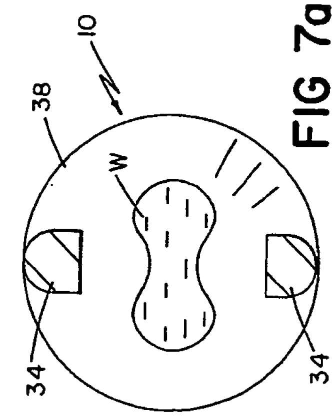



FIG 6a

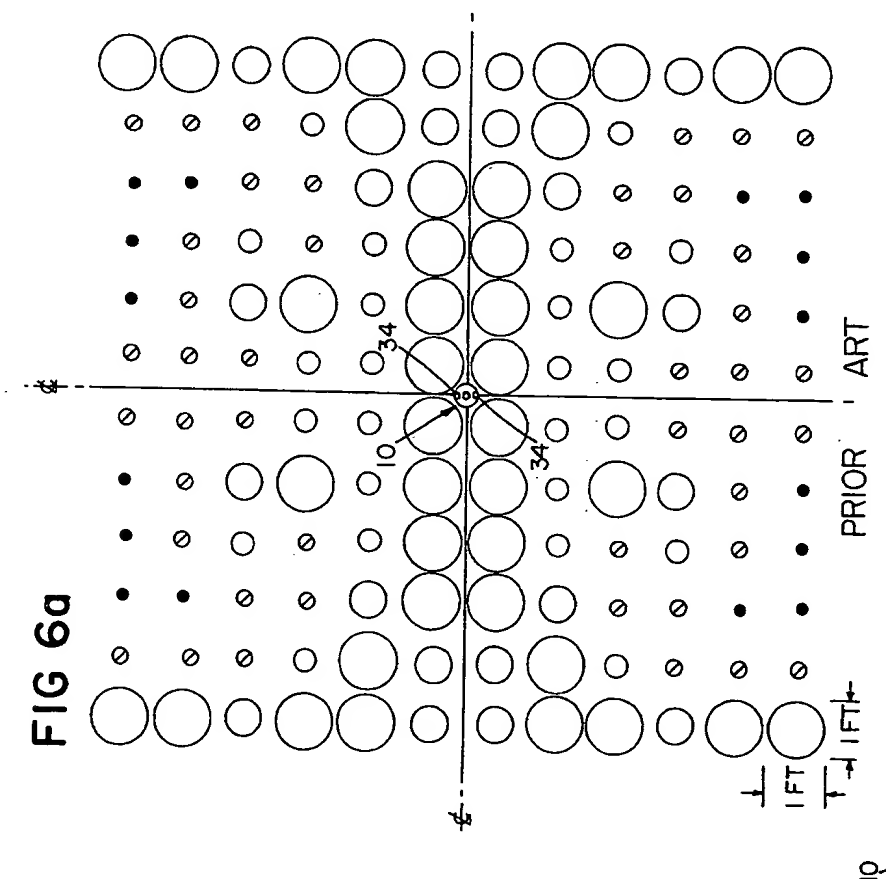
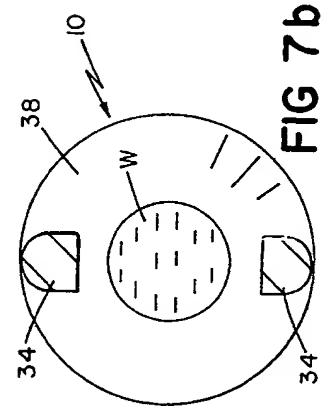



FIG 7b




PRIOR ART

# SPRINKLER HEAD WITH NONCIRCULAR THROAT

## FIELD OF THE INVENTION

This invention relates to fire-protection sprinkler heads.

## BACKGROUND OF THE INVENTION

It is generally desirable for a fire-protection sprinkler head to deliver a fairly uniform spray pattern. In most sprinkler heads, the spray pattern is developed by directing a stream of water (or other fire-retardant liquid) from a throat (generally frustoconical in shape) against a deflector spaced a short distance from the throat. The deflector is generally supported at the region where two curved arms extending from the throat area meet. The arms do more than support the deflector; they generally support a strut member that holds a sealing button against the throat opening, and thus they are typically of substantial size. Their size as well as numerous other factors have an influence on the spray pattern.

## SUMMARY OF THE INVENTION

It has been found that in certain sprinkler heads, for example, those having the deflector attached on the far side of the arms and those installed such that there is little turbulence in the stream emerging from the throat, the arms have a much greater influence on the spray pattern than has previously been appreciated. This latter situation occurs when a sprinkler head is installed at the end of substantially straight length of pipe rather than very near a tee or elbow fitting. The length of straight pipe allows the flow to become more laminar. When a tee or elbow fitting immediately precedes the sprinkler head, the flow has turbulence which permits the water to tend to wrap around the arms and minimize their effects. The invention is particularly useful in low flow rate (e.g., 20 gpm) applications, wherein a nonuniform spray pattern can result in some floor areas receiving undesirably low flow rates.

It has been found that the spray pattern can be controlled by varying the cross-sectional shape of the throat, and that the shape can preferrably be selected to overcome the problems caused by lamination of the flow. Instead of the conventional circular corss section, the throat is provided with a non-circular cross section selected to produce a selected spray pattern. The invention allows other existing nonuniformities in the pattern to be corrected, and as well enables desired nonuniformities to be intentionally produced.

In preferred embodiments, the throat is also tapered (e.g., frustoconical) along the longitudinal axis to reduce the throat area in the direction of flow; the tapered portion is enlarged at two diametrically opposed sides to produce an elongated or oblong transverse cross section; the enlargement is a slot with a width less than the largest diameter of the tapered portion and with a length greater than that width; the throat is defined by an inset which is inserted into a larger throat in the base; the elongation of the throat axis is along an axis directed away from the arms (e.g., perpendicular to the plane in which the arms lie); curved arms extend from the base to a junction from which the deflector plate is supported; the taper and elongated cross section are selected to produce a flow stream emerging from the throat with a dumbbell-shaped cross section; and the deflector plate is positioned on the far side of the junction. In these preferred embodiments, the throat produces a nonuniform-cross-section flow stream which produces a spray pattern that is more uniform on the average than the prior art. Further, the dumbbell-shaped cross section helps spread the flow to either side of the arms and thereby further help make the spray pattern more uniform.



## PREFERRED EMBODIMENT

The structure and operation of a preferred embodiment of the invention will now be described, after first briefly describing the drawings.

## DRAWINGS

FIG. 1 is an elevation view of sprinkler heads installed in two different manners.

FIG. 2 is a cross-sectional view through a sprinkler head embodying the invention and showing a partial cross sectional view of the throat.

FIG. 3 is an enlarged view looking down at the inlet of the throat insert of FIG. 2.

FIG. 4 is a cross-sectional view at 4—4 of FIG. 3.

FIG. 5 is a cross-sectional view at 5—5 of FIG. 3.

FIGS. 6*a* and 6*b* are diagrammatic views of test results of the spray pattern achieved with and without the invention at a flow rate of 20 gpm.

FIGS. 7*a* and 7*b* are cross sectional views at 8—8 of FIG. 2, showing the cross section of the water stream emerging from the throat of the sprinkler head for the preferred embodiment (FIG. 7*a*) and for the prior art (FIG. 7*b*).

## STRUCTURE

Turning to FIG. 1, there is shown sprinkler head **10** installed with two different supply pipe configurations: directly on a tee fitting **12** (1 by 1 by ½ inch National Pipe Thread, NPT) and at the end of a nipple **14** (1 inch NPT) via reducing coupling **16** (1 inch to ½ inch NPT) and tee fitting **18** (all 1 inch NPT). The nipple arrangement is common in applications when the sprinkler head is installed in a ceiling. In this structure, the main supply line **20** (1 inch NPT) is routed above the ceiling, and the head **10** is brought down to the height of the ceiling by nipple **14**.

Turning to FIG. 2, there is shown a cross section of sprinkler head **10**. Body **30** (a machined bronze casting) has internal passage **31** and threads **32** for attachment to a supply fitting. Integral arms **34** (only one shown in FIG. 2) extend from the base downward to apex **36**, to which is attached deflector plate **38**. Passage **31** is normally sealed shut by button **40** and gasket **42**, which are supported by strut **44**. The base of strut **44** rests in a groove in hook **45**, the groove being offset slightly from fulcrum **46** on the apex, to provide mechanical advantage. Hook **45** is secured via curved member **48**, solder layer **50** and heat collector **52** to the strut **44**.

Within passage **31** there is installed an inset **60**, which has a throat **61** with an oblong cross section. The cross section is elongated along an axis X (FIG. 3) perpendicular to the plane in which the two arms **34** lie. The outside surface **62** of the inset is frustoconical and matches the frustoconical interior surface of the throat. The inset is shown in more detail in FIGS. 3 to 6. Outside maximum diameter A is 0.5575 to 0.5555 inches. The outside taper is 1 11/16 inches per foot. Length B is 13/16 inch. The inside of insert **60** is machined by first producing a frustoconical surface with a taper identical

to the outside taper and having an internal diameter of 0.220 to 0.223 inches at the downstream end. An end mill is then used to cut a slot 0.22 inches wide by 0.43 inches long. The ends of the slot are semicylindrical, and the axis of the end mill is parallel to the axis of the inset. Intersections of the end-milled surfaces 70, 72 with frustoconical surface 74 can be seen in FIG. 4.

## OPERATION

When the sprinkler is activated (by melting of solder layer 50), strut 44 and button 40 are released, and water flows through throat 61 in a stream directed at deflector plate 38, which produces a spray in all directions. The elongated cross section of throat 61 produces a stream of water W, which has the cross section illustrated in FIG. 7a. This cross section can be described ad dumbbell shaped, as the section is enlarged at two ends. But unlike an actual dumbbell, the section has substantial thickness midway between the enlarged ends. The prior-art circular throat produces a roughly constant circular stream cross section, as illustrated in FIG. 7b. Elongation of the water stream tends to spread a greater fraction of the water to either side of the arms and thereby reduce the volume of water whose flow path is disturbed by arms 34. The dumbbell shape further enhances such spreading to either side of the arms, producing a more uniform spray coverage. Both factors—elongation of the throat and stream as well as dumbbell shape—contribute to the uniformity of the spray pattern.

Tests were conducted to compare the performance of the oblong throat with that of the prior-art circular throat. These results are presented in FIG. 6. Pans roughly one foot square were arranged in the pattern shown by the squares of FIG. 6, and the amount of water was measured that fell in the pans during five minutes of spraying from a sprinkler positioned at the center of the pattern. The size of the circles 80 is an indication of the volume of water collected in each square pan or square area 82 in a unit of time (i.e., gpm/ft$^2$). FIG. 6b shows the improved spray pattern achieved with the oblong throat. FIG. 6a shows that spray pattern achieved with the prior-art circular throat. The prior art pattern has more squares with flow rates in the lowest two ranges (0.005–0.019 and 0.020–0.039 gpm/ft$^2$), and only the prior art pattern has squares with flow rates in the lowest range. These areas of lower flow rates are generally in the shadow of arms 34. All the tests were conducted with the sprinkler head connected to a supply pipe in the nipple configuration of FIG. 1 with a 24 inch long nipple.

Other embodiments of the invention are within the following claims. For example, the inset throat could have a different, non-circular cross section, and the noncircular throat could be cut directly in base 30, thereby eliminating the inset.

What is claimed is:

1. In a fire-protection sprinkler head of the type including a base, a throat in said base through which fire-retardant fluid can flow, a deflector plate spaced away from said base, and one or more arms extending from said base for supporting said deflector plate, whereby when flow through said throat is established fluid emerges from said throat in a stream which impinges on said plate and is deflected in a spray pattern, said arms being located so that they tend to obstruct the flow of said fluid so as to produce shadow areas in said spray pattern where the spray density is lower than average, the improvement wherein the transverse cross section of said throat is noncircular and elongated principally along a single axis directed away from said arms, said elongation being such that, in any said transverse cross section, the dimension of said throat in the general direction of said single axis is greater than the dimension in any other direction and such that said single axis has the same orientation along the entire axial length of the throat, the shape of said elongated cross section being selected so that said stream emerging from said throat is also elongated away from said arms, thereby spreading portions of said stream away from said arms so as to reduce the obstructing influence of said arms and thereby increase the density of said spray pattern in said shadow areas.

2. The sprinkler head of claim 1 wherein said throat includes a portion tapered along its longitudinal axis so that the transverse area of said portion is reduced in the flow direction.

3. The sprinkler head of claim 1 wherein said throat includes a frustoconical portion and two diametrically-opposed enlargements along the single axis of elongation, and in said transverse cross section the width of said enlargements along a direction perpendicular to said single axis of elongation being less than the maximum diameter of said frustoconical portion.

4. The sprinkler head of claim 2 wherein said noncircular cross section is adapted to produce a dumbbell-shaped transverse cross section in the flow stream emerging from said throat, said dumbbell-shaped cross section having two enlarged end portions connected by a middle portion of substantial thickness.

5. The sprinkler head of claim 4 wherein said arms extend from said base to a junction from which said deflector plate is supported and wherein said dumbbell shape is aligned so that the two enlarged end portions are directed away from said arms.

6. The sprinkler head of claim 1 wherein said arms lie substantially in one plane and said single axis of elongation of said throat is substantially perpendicular to said plane.

7. The sprinkler head of claim 1 wherein said arms extend from said base to a junction and said deflector plate is mounted on the side of said junction farthest from said throat, whereby portions of said stream of fluid impinge on said arms and junction before reaching said deflector plate.

8. The sprinkler head of claim 1 further comprising an inset fitting within a hole in said base, said inset including the noncircular transverse cross section defining said throat.

9. The sprinkler head of claim 1 further comprising temperature-responsive means for controlling flow from said throat.

* * * * *

**United States Patent** [19]
**Fischer et al.**

[11] **4,273,195**
[45] **Jun. 16, 1981**

[54] **FIRE PROTECTION SPRINKLER HEAD WITH AIR-CURRENT DIVERTING FINS**

[75] Inventors: **Michael A. Fischer**, North Kingstwon, R.I.; **Jerome S. Pepi**, North Attleboro, Mass.

[73] Assignee: **Grinnell Fire Protection Systems Company, Inc.**, Providence, R.I.

[21] Appl. No.: **34,636**

[22] Filed: **Apr. 30, 1979**

[51] **Int. Cl.**³ ........ **A62C 37/12**
[52] **U.S. Cl.** ........ **169/39; 169/42**
[58] **Field of Search** ........ 169/37–42, 169/57, 90

[56] **References Cited**

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*Primary Examiner*—F. J. Bartuska
*Assistant Examiner*—Fred A. Silverberg

[57] **ABSTRACT**

A fire-protection sprinkler head with an improved response characteristic achieved by providing a fusible link with a fin having multiple face portions oriented to direct air currents from any of a plurality of orthogonal directions over the fusible region of the link. An embodiment with multiple fins provides an aggregate set of face portions that direct over the fusible region air currents that have X, Y, and Z orthogonal components in both positive and negative senses. Air currents can be directed both by deflecting effects and air foil effects. Preferably the face portions are facets formed integrally with sheet metal body members that form the link. In the preferred embodiment the link and all fins are formed of a pair of similar stampings from sheet metal.

**12 Claims, 12 Drawing Figures**

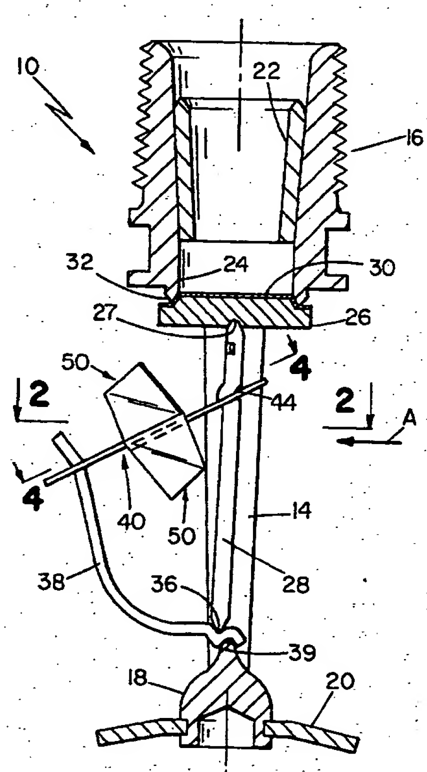
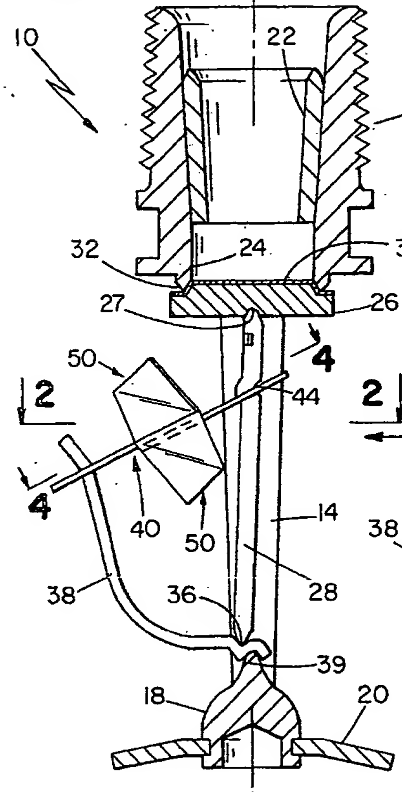


FIG 1



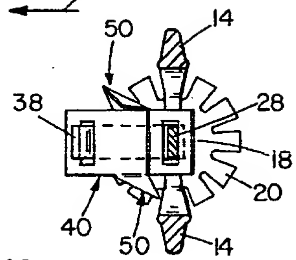




FIG 2

FIG 3

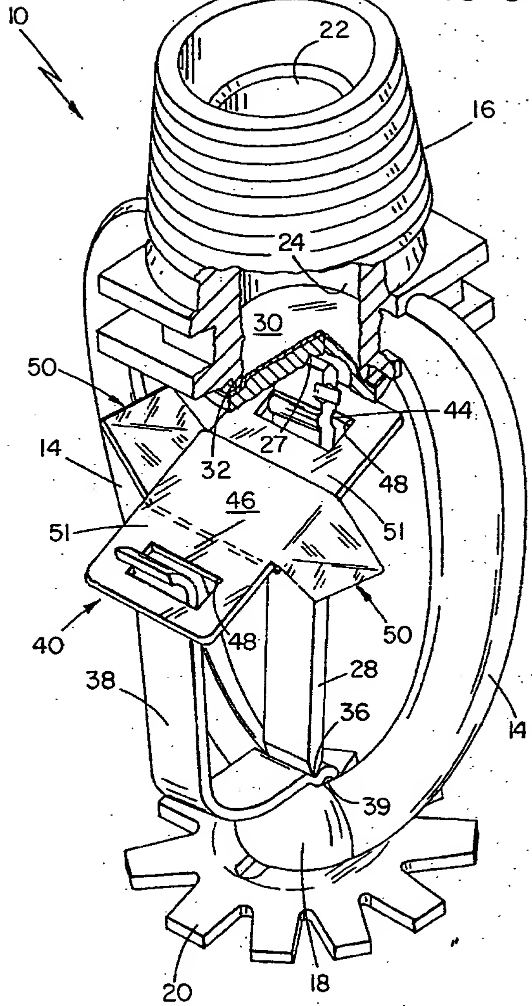
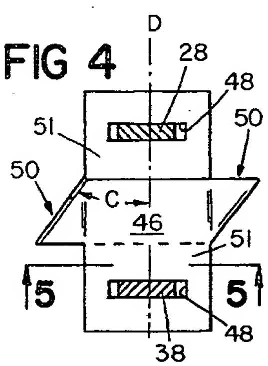



FIG 4



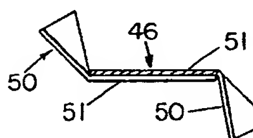




FIG 5

FIG 6

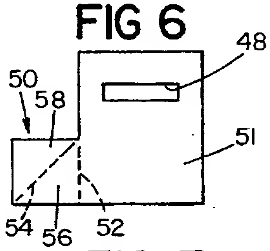
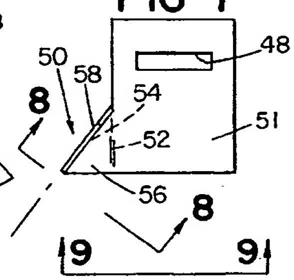



FIG 7



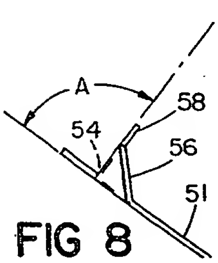




FIG 8

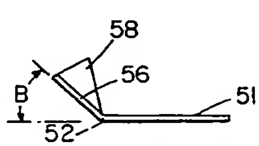



FIG 9

FIG 10

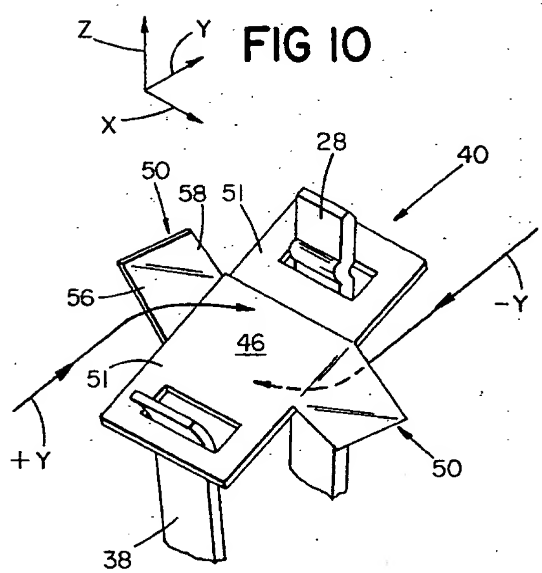


FIG 12

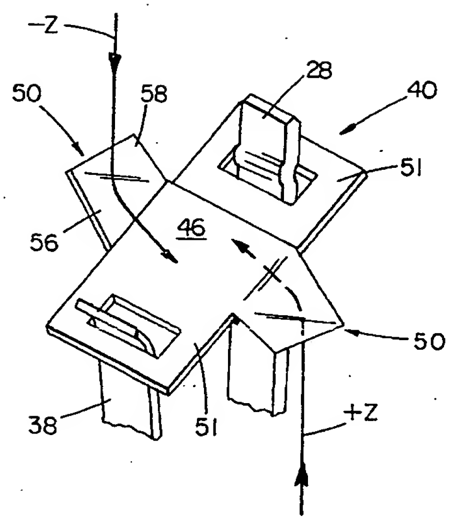
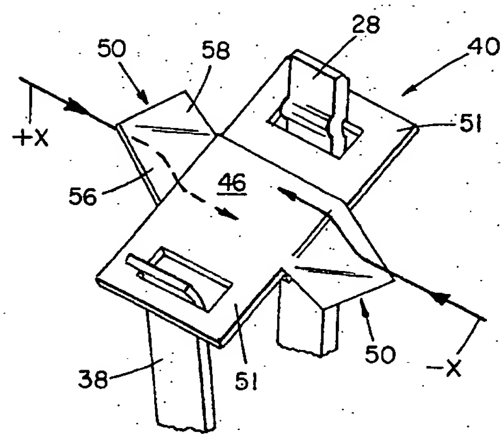



FIG 11



## FIRE PROTECTION SPRINKLER HEAD WITH AIR-CURRENT DIVERTING FINS

### FIELD OF THE INVENTION

This invention relates to automatic sprinkler heads for fire protection.

### BACKGROUND OF THE INVENTION

Automatic sprinkler heads with temperature-responsive fusible elements have long been used in all types of buildings for fire protection. There is a need, however, for a sprinkler especially suited for residential use. In the past, residential sprinklers were of the type originally developed for factories and like applications. To serve in residential applications, a sprinkler valve should have a faster (e.g., a factor of four) response time than has been needed in many conventional applications, i.e., it must turn on sooner at a given air temperature. The faster response is needed to detect the presence of a fire soon enough to prevent buildup of noxious gases (e.g., carbon monoxide) from burning materials (e.g., plastics) commonly found in residences. The faster response is also desired to better contain and extinguish flames.

Government and industry organizations have conducted research on the required speed of response, which indicates that a 21 second or smaller time constant is necessary. The time constant is measured as the period of time required for the fusible element in the sprinkler to achieve 63% of the rise in temperature occasioned by inserting the sprinkler from ambient into a stream of heated air flowing through a duct. For example, were the sprinkler moved from equilibrium at 70° F. into a stream of 360° F. air, the time constant would be the amount of time required for the fusible element to reach 63% of the total rise in temperature, or 63% of 290° F. The time constant is not, of course, necessarily the amount of time required to turn on the sprinkler in a fire, but rather an indication of the relative speed of response.

To obtain a fast response, prior sprinkler heads (e.g., Russell U.S. Pat. No. 1,834,319, Loepsinger U.S. Pat. No. 1,919,235, and Russell U.S. Pat. No. 1,932,805) have employed sheet-metal linkage members in contact with a fusible medium to reduce the thermal mass to be heated, and have added fins and flanges to the linkage members to conduct heat toward the fusible element. Russell U.S. Pat. No. 1,932,805 also teaches that flanges extending along the curved edges of one of the sheet-metal pieces can direct rising currents of warm air against the soldered surfaces between the flanges. Other efforts in the field are Teague U.S. Pat. No. 1,300,046, Loepsinger et al. U.S. Pat. No. 2,075,816, and Gloeckler U.S. Pat. No. 3,874,456.

### SUMMARY OF THE INVENTION

It has been found that faster sprinkler response times, low enough to meet the above-mentioned 21 second test, can be achieved by providing a fusible link with a fin having multiple face portions oriented in different directions to divert air currents from any of a plurality of orthogonal directions over the fusible region of the link.

In preferred embodiments, a plurality of fins each with multiple face portions serve to divert mutually orthogonal X, Y, and Z air current components over the fusible region, e.g., two of the components being horizontal and the other vertical; two of the fins are on opposite transverse sides of the link; the two fins are each an integral extension of one member; the fusible region is planar and one of the two fins extends above the planar region and the other of the two fins extends below the planar region, whereby air diverted over the fusible region by one fin is not retarded in moving away from the link by the second fin and thus heat transfer is enhanced by a continuous movement of air across the fusible region; a first face portion (e.g., outboard) is positioned and inclined with respect to the X air current components and a second face portion (e.g., inboard of the outboard portion) is positioned and inclined with respect to the Z air current components; the inclination of the second face portion also has an air-foil effect (e.g., from a convex surface) and diverts Y air current components tending to pass below the planar fusible region to a course passing over the upper surface of the region and Y components tending to pass above the region to a course passing over the lower surface of the region; the face portions are planar facets connected by bend regions; the axis of curvature of the outboard bend region is skewed with respect to the axis of the inboard bend region; the outboard facets are substantially perpendicular to the planar fusible region and the normals of the outboard facets are inclined at about 45 degrees to the Y air currents and to the direction of elongation of the link; the inboard facet forms a concave surface on the other side to provide the air-foil to divert the Y components; the fin mass constitutes less than 20% of the total mass of the link; the sprinkler head further includes a generally vertical strut engaging a plug member that seals the passage through which fire-retardant fluid flows, the strut shadowing the link from some of the air currents while one or more fins lie out of the shadow to intercept the air currents; the sheet metal members forming the two halves of the link are rectangular and overlap each other longitudinally from 20 to 80 percent of the area of each member; the fins are square before bending and the second bend runs along a diagonal of the square to form two equal-area triangular facets that form the face portions; and the link weighs 0.8 gram and has a time constant of 21 seconds.

### PREFERRED EMBODIMENT

The structure and operation of a preferred embodiment of the invention will now be described, after first briefly describing the drawings.

### DRAWINGS

FIG. 1 is a vertical, partially cross-sectional, view of said embodiment.

FIG. 2 is a horizontal cross-sectional view at 2—2 of FIG. 1.

FIG. 3 is a perspective view of said embodiment.

FIG. 4 is a view at 4—4 of FIG. 1, showing the fusible link.

FIG. 5 is a cross-sectional view at 5—5 of FIG. 4.

FIG. 6 is a view of one portion of the fusible link before bending the fin element, showing fold lines for the element.

FIG. 7 is the same view as FIG. 5 with the fin element bent along its two fold lines.

FIG. 8 is a projection taken at 8—8 of FIG. 7, showing that one surface of the fin element is substantially at a right angle with respect to the surface of the fusible link.

FIG. 9 is a projection taken at 9—9 of FIG. 7.

FIGS. 10, 11, and 12 are perspective views of the fusible link, illustrating the diversion of X, Y and Z air current components onto the fusible region of the link by the fins.

## STRUCTURE

Turning to FIGS. 1-3, there is shown automatic fire sprinkler head 10. The sprinkler consists of a valve body with curved arms 14 extending down from a threaded end 16 to an apex 18, at which a spray deflector 20 is attached. Threaded end 16 is screwed into a fitting in the piping system of a pressurized water (or other fire-retardant fluid) supply system. Bushing 22 fits within passage 24, and reduces the orifice size to enhance the spray pattern.

Sealing the outlet of passage 24 is button 26 held in place by strut 28 (silicon bronze, ASTM B97, Alloy 655). Gasket 30 (soft, annealed copper) is deformed between button 26 and sharp edge 32 extending around the outlet of passage 24.

Strut 28 extends between an abutment groove 27 on the underside of button 26 and another groove 36 in a resilient lever 38. Groove 36 is slightly offset from the vertical centerline of passage 24. The lever 38 pivots on ridge 39 which is positioned at the centerline of the passage. Lever 38 is held in place by fusible link 40 extending between the top end of the lever and groove 44 in strut 28.

Fusible link 40 consists of two halves 51 (mirror images of each other) made of copper sheet metal (about 11 mils thick; 0.48 inches wide; 0.575 inches long) laminated with solder (1 to 4 mils thick) in a lap joint (0.25 inch overlap between halves) at fusible region 46 of the link. Each half 51 of the link has an aperture 48 and a fin element 50.

Referring to FIGS. 6-9, each fin element is cut as a square tab (0.25 by 0.25 inches) extending laterally from one side of each piece 51 of the link. The element is then formed by bending along two bend lines 52, 54 to form equal area inner and outer fin facets 56, 58, respectively. As can be seen in the projection of FIG. 8, outer facet 58 makes a right angle A (88 to 90 degrees) with the main surface of the fusible link. Inner facet 56 is oriented at an angle B of between 43 and 47 degrees with the main surface of the fusible link. The combined effect of the two bends is to orient outer facet 58 so that it is at an acute angle C relative to the longitudinal direction D (longitudinal plane of symmetry) of the fusible link. The whole fusible link has a mass of about 0.8 grams.

## OPERATION

Sprinkler head 10 is installed either as shown with the passage centerline vertical or rotated 90° to make the centerline horizontal.

Under normal conditions, in the absence of fire, fusible link 40 can provide sufficient restraining force (about 10 lb) on lever 38 to maintain the seal of gasket 30 against valve seat 32. A large mechanical advantage is provided by the small offset of strut 28 from the fulcrum formed by ridge 39. Fusible link 40 is spaced a much greater distance from the fulcrum than the strut, such that a 10 lb force from link 40 produces a substantially greater upward force (about 200 lb) on button 26.

When link 40 is heated sufficiently to cause the solder laminating its two halves 51 to approach melting temperature (about 136.5° F.) and thereby lose its strength, the two halves, being under tension, separate. This allows lever 38 to rotate downward and away from the passage centerline, thereby removing the force on strut 28, button 26, and gasket 30. The various parts are blown away by water exiting from the outlet of passage 24. Fluid strikes deflector plate 20, producing a fine spray which is distributed over a wide area. The spray pattern depends on the configuration of the deflector plate and on the flow rate from passage 24. The flow rate is adjustable by changing the internal area of bushing 22.

The key to the fast response of the sprinkler regardless of the location of the fire is the provision of fin facets 50 for diverting the warm air currents generated by the fire onto the fusible region. Without the facets, these air currents would pass by the link without transferring heat.

The air currents can be resolved into components in the X, Y, and Z directions shown by the axes of FIG. 10. The axes are referenced to the sprinkler body with the Z axis parallel to the centerline of passage 24. As shown, with the centerline vertical, the X and Y directions are horizontal, and the Z direction is vertical. If the sprinkler were installed horizontally, either the X and Z or the Y and Z directions would instead be horizontal, depending upon the chosen rotational orientation of the sprinkler head.

When a fire occurs off to the side of the sprinkler head, the predominant air currents are horizontal, and thus are along the X and Y directions when the sprinkler head is installed as shown. If the sprinkler is installed horizontally, the predominant air currents would be along the X and Y or X and Z directions.

FIGS. 10, 11, and 12 illustrate how air currents of each of the X, Y, and Z directions are diverted onto the fusible region 46. Air currents in the +Y or −Y directions (i.e. in either a positive or negative sense along the coordinate) are diverted by outer facets 58 which are inclined at an acute angle C with respect to the Y direction. Air currents in the +Z and −Z directions are diverted along the concave surface formed by inner facet 56 which is set at an angle B with respect to the plane of the link. Air currents in the +X and −X directions are diverted by an air-foil effect along the convex surface formed by the opposite side of facet 56. In the instance when the air currents are not resolved exactly along either direction, the air diversion will be a combination of the effects illustrated.

Other embodiments are within the scope of the following claims. For example, the fusible link 40 could be nonplanar (e.g., semicylindrical) and it could have various positions with respect to the passage centerline, under either tension or compression load. In this embodiment and others in which the link is not substantially horizontal, the axes for resolving air currents should be referenced to the link itself in order to be consistent with the above explanation of air diversion. The X and Y directions would be parallel to the link and the Z direction normal to the link. In the preferred embodiment, the link is only slightly inclined from the horizontal, and thus there is little difference between the two sets of axes.

What is claimed is:

1. In a fire-protection sprinkler head with a fusible link, a passage in the head through which fire-retardant fluid can flow, and a closure for said passage, said link including two sheet-metal members joined at a fusible region by a fusible medium, each said member being engaged with another portion of said sprinkler head and

said link being under load in its longitudinal direction and in a manner to hold said closure in position to close said passage, said members being adapted to release said load upon melting of said fusible medium to thereby release said closure to open said passage and allow flow of said fluid, the improvement wherein

said fusible link includes at least two sheet-metal fins each of which has first and second face portions oriented in different directions to enable said fins to divert air currents from a plurality of orthogonal directions over said fusible region,

said fusible region is generally planar and has two opposite generally longitudinally extending edges,

said fins extend from said edges,

any said fin extending from the first of said edges extends away from said link in such a direction that said fin lies on one side of the plane passing through said planar region,

any said fin extending from the second of said edges extends away from said link in such a direction that said fin lies on the other side of said plane passing through said planar region,

whereby air diverted over said fusible region by the fin extending from said first edge is not retarded in moving away from said link by the fin extending from said second edge and thus heat transfer is enhanced by a continuous movement of air across said fusible region.

2. In a fire-protection sprinkler head with a fusible link, a passage in the head through which fire-retardant fluid can flow, and a closure for said passage, said link including two members joined at a fusible region by a fusible medium, each said member being engaged with another portion of said sprinkler head and said link being under load in a manner to hold said closure in position to close said passage, said members being adapted to release said load upon melting of said fusible medium to thereby release said closure to open said passage and allow flow of said fluid, the improvement wherein

said first face portions being formed by outboard portions of said fins and said second face portions being formed by inboard portions of said fins, and

said first face portion being an outboard, planar facet and said second face portion being an inboard, planar facet and said inboard facet being connected to said outboard facet and the body of said member by inboard and outboard bend regions.

3. The sprinkler head of claim 2 wherein

said inboard facet of each said fin is inclined at an obtuse angle with respect to said fusible region and

said inboard facet, inboard bend region, and fusible region form a concave surface along which said Z air currents are diverted.

4. The sprinkler head of claim 3 wherein

said outboard facet of each said fin is inclined at an obtuse angle with respect to said inboard facet and the axis of curvature of said outboard bend region is skewed with respect to the axis of said inboard bend region.

5. The sprinkler head of claim 4 wherein said outboard facets are substantially perpendicular to said planar fusible region and the normals of said outboard facets are inclined at about 45 degrees to the longitudinal plane of symmetry of said link, whereby said outboard facets are inclined to said Y air currents.

6. The sprinkler head of claim 3 wherein said inboard facet, inboard bend region, and fusible region form a convex surface, on the side opposite said concave surface, along which said Y air currents are diverted by said air-foil effect onto said fusible region.

7. In a fire-protection sprinkler head with a fusible link, a passage in the head through which fire-retardant fluid can flow, and a closure for said passage, said link including two sheet-metal members joined at a fusible region by a fusible medium, each said member being engaged with another portion of said sprinkler head and said link being under load in a manner to hold said closure in position to close said passage, said members being adapted to release said load upon melting of said fusible medium to thereby release said closure to open said passage and allow flow of said fluid, the improvement wherein

said fusible link includes at least one sheet-metal fin having multiple face portions with different face portions oriented in different directions to enable said fin to divert air currents from a plurality of orthogonal directions over said fusible region, and

said head further comprises a body having said passage, a strut generally axial to the passage engaging a plug member that forms said closure means and seals said passage through which fire-retardant fluid flows, a fulcrum member near the other end of said vertical strut and supported by a pair of arms extending from said body, a lever member acting as a lever between said fulcrum member and said vertical strut, said link extending between said lever member and said strut to supply a holding force to the lever to force said strut against said plug member,

said sheet-metal members are rectangular and overlap each other longitudinally from 20 to 80 percent of the area of each member,

said fusible layer extends over the region of overlap,

one said fin is an integral extension of one of said sheet-metal members and another fin is an integral extension of the other of said members, and

said face portions are planar facets formed by two bend regions on each fin, one bend parallel to the longitudinal axis of said link and located at the boundary between each said fin and member, and the other bend being spaced outward and skewed from the first bend.

8. The sprinkler head of claim 7 wherein said fins are square before bending and said second bend runs along a diagonal of the square to form two equal-area triangular facets that form said face portions.

9. The sprinkler head of claim 7 wherein said link weighs less than 1.0 gram and has a time constant of less than 25 seconds.

10. The sprinkler head of claim 9 wherein said link weighs about 0.8 grams and has a time constant of less than or equal to 21 seconds.

11. The sprinkler of claim 7 wherein said outer facet is about at right angles to the plane of said link.

12. The sprinkler of claim 11 wherein said inner facet is about at 45 degrees to the plane of said link.

* * * * *

UNITED STATES PATENT OFFICE 

# CERTIFICATE OF CORRECTION

Patent No. 4,273,195 Dated June 16, 1981

Inventor(s) MICHAEL A. FISCHER, ET AL.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Page 1, Column 1, application number "34,636" should be --34,686--.

Claim 2, Column 5, line 40, after "wherein" insert

--said fusible link includes two fins each with multiple face portions, the aggregate set of face portions being relatively oriented and sufficient in number to divert X, Y, and Z air current components over said fusible region,

one of said air current components being parallel to a first horizontal direction in the three-dimensional space surrounding said sprinkler head, another said component being parallel to a second horizontal direction perpendicular to said

UNITED STATES PATENT OFFICE 

# CERTIFICATE OF CORRECTION

Patent No. 4,273,195 Dated June 16, 1981

Inventor(s) MICHAEL A. FISCHER, ET AL.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

first, and the third component being parallel to the vertical direction in said space,

said two fins being on opposite transverse sides of said link,

said first face portion being positioned and inclined with respect to said X air current components to divert them from a course passing by said fusible region to a course passing over said region and

said second face portion being positioned and inclined with respect to said Z air current components to divert them from a course passing by said fusible region to a course passing over said region,

UNITED STATES PATENT OFFICE

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Inventor(s) MICHAEL A. FISCHER, ET AL.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

the inclination of said second face portion also having an air-foil effect and diverting Y air current components tending to pass below said fusible region to a course passing over the upper surface of said region and Y air current components tending to pass above said region to a course passing over the lower surface of said region, --

**Signed and Sealed this**

*First* **Day of** *February 1983*

[SEAL]

*Attest:*

GERALD J. MOSSINGHOFF

*Attesting Officer* *Commissioner of Patents and Trademarks*